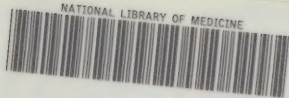
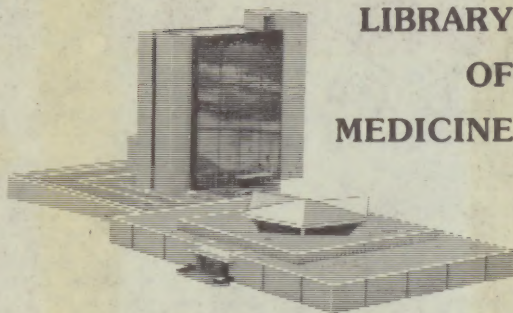


NATIONAL LIBRARY OF MEDICINE



NLM 00043134 9

**U.S. NATIONAL
LIBRARY
OF
MEDICINE**



QT
104
C976h
1917

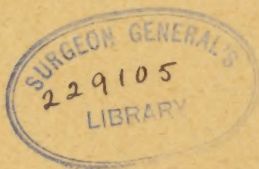
**HEALTH TALKS TO
YOUNG PEOPLE**

THE HUMAN BODY

AND THE WORK WHICH IT DOES

A Brief Consideration of the Fundamental
Facts of Anatomy, Physiology and Hygiene

nd 4043 ✓
By A. F. CURRIER, M. D.
111



The  Globe
AND Commercial Advertiser.

73 Dey Street, New York

Copyright The Commercial Advertiser Association, 1917.

QT

104

C976h

1917

File 7394 item 3

PREFACE

The following pages are a reproduction in connected and systematic form of articles which appeared from time to time in 1916 and 1917 in the medical column of the *New York Evening Globe*. Such questions as health, the structure of the human body, and its various methods of doing work are always and necessarily of great interest and in every period of the world's history there has been a desire to be informed about them. For one reason and another this knowledge has not been generally attainable in language or in terms that could be comprehended and assimilated. At the present time when the daily press, the universal educator, is providing the public with information on every conceivable subject, it is not in the least strange that the public should turn to it for reliable information on that which is of the utmost concern alike to individuals and communities, physical welfare.

The great war in which so large a portion of the world is now engaged with its colossal tale of sickness and injury has stimulated almost everybody to find out what these sicknesses and injuries mean and what their relation to the body in general and to life. It will be a long time before civilized beings are again indifferent to the problems of life. The exigencies of the war have also compelled us who must remain at home to consider as never before questions such as food, heat, exercise, sleep, sanitation and kindred subjects in order that we may best serve and co-operate with our boys at the front. It is with the hope that these pages may supply some of this needed and needful knowledge that they are now offered to the public. It must be emphasized that the facts here enunciated, though fundamental, are but beginnings. If they stimulate those who read them to search for further information they will have accomplished a useful purpose.

Several of the cuts in this book are reproduced from the book of my friend, Dr. A. H. Doty, *Good Health, How to Get It, How to Keep It*, with his kind permission and that of his publishers, Messrs. D. Appleton & Co. I desire to thank them both for this privilege and courtesy.

ANDREW F. CURRIER, M.D.

New York, December, 1917.

FEB 18 1918

©CLA481819

CHAPTER I

THE HUMAN BODY

The human body is the most wonderful machine that ever was constructed. We admire the intricate and beautiful structure and working of an automobile, a printing press, an electrical engine, and other machines of which this age has produced so many; but not one of them is to be compared with the human machine in interest or in the power of effective work.

In the first place, all these machines are the product of the human machine—its children, as it were; and the thing created cannot be as important or as capable as that which created it. A machine may seem to have portions of the human mind transferred to it, so that it can add figures or pick up things or select certain things from certain others; but these and many other wonderful achievements are not possible until the hands and brain of the human machine have put it together—and it can never do anything more than they designed that it should do.

The human body starts from an egg too small to be seen with the naked eye, and from the very first moment of its existence it is endowed with that mysterious quality which we call life, and which impresses upon it the capability of continual change as long as it remains in contact with it. Take life away, and growth stops at once, whether it be the moment after life has begun or a hundred years later. Life, therefore, is the one thing above all others which must be preserved if the body is to show the slightest particle of progressive change. If life persists in the egg the egg divides—one cell becomes two, two become four; it keeps on dividing, and by and by a faint outline or streak appears, the first indication that the beginning of a body has been made. New structures are quickly formed, which, like a veil, surround and protect it or afford provision for its nourishment. The egg forms attachment to maternal structures and becomes a part of them—its life a part of their life. In due time there is sprouting of arms and legs, the cavities of the body are enclosed, the various organs are formed. At length the fruit is ripe—a new body has finished its first stage of existence and makes its way into the world, just as an apple drops from the tree when it no longer needs the sustaining juices of the parent twig.

Growth now takes another form. The body has need of air, and light, and sleep, and food, and exercise. Change continues, the cells of the body multiply, and it becomes larger, longer, and wider. The different functions are established, various foods are taken, digested, and distributed to the cells as these require them. The mind begins to work, knowledge is acquired; the reason, the will, the emotions begin to grow. Then, on the threshold between childhood and maturity, the reproductive sense is born and the most important changes for the maintenance of physical life are imposed—often with the greatest rudeness—upon the developing body.

Maturity of the body is followed by maturity of the mind, but there is no cessation of activity in the cells as long as life remains; changes in the body structure persist continually. Food is taken and is transformed into tissue; air and exercise and sleep are called for without cessation. The cells wear out, are disintegrated and carried off as waste matter; and this process continues until what we call death puts a stop to it.

Now, the important thing in this complicated procedure is to see that the wants of the body are adequately met; not too much food nor too little, not

too much heat nor too much cold, not too much exercise nor too little, a sufficiency of sleep and of fresh air, plenty of water. When these balances are found and the adjustments made, the human machine, in the great majority of cases, runs smoothly.

It is because people neglect to observe these requirements that the machinery gets out of order and requires doctors and medicines, like all other kinds of machinery. It should be the study of life, from childhood to old age, to find out, in each individual case, what these necessary conditions are.

CHAPTER II

THE STRUCTURE OF THE HUMAN BODY

The structure or make-up of the body forms the science of anatomy, and about everything in or upon it is now known and classified. Reversing the process used by children in putting together a picture puzzle we see how this science of anatomy has been built up—in other words the body has been taken apart, piece by piece, down to its very cells hundreds and thousands of times, and, the results being nearly uniform, we have a fixed standard when we speak of its anatomy or that of any of its parts.

The separating of the parts of the body from each other is called dissection. The larger parts can be seen with the naked eye and easily handled, but we should never have known how minutely these parts could be subdivided if it had not been for the microscope, which enormously enlarges objects too small for the unaided vision. Knowing all the elements of the body down to its very cells it is easy to dispose them in their proper places and form the complete structure.

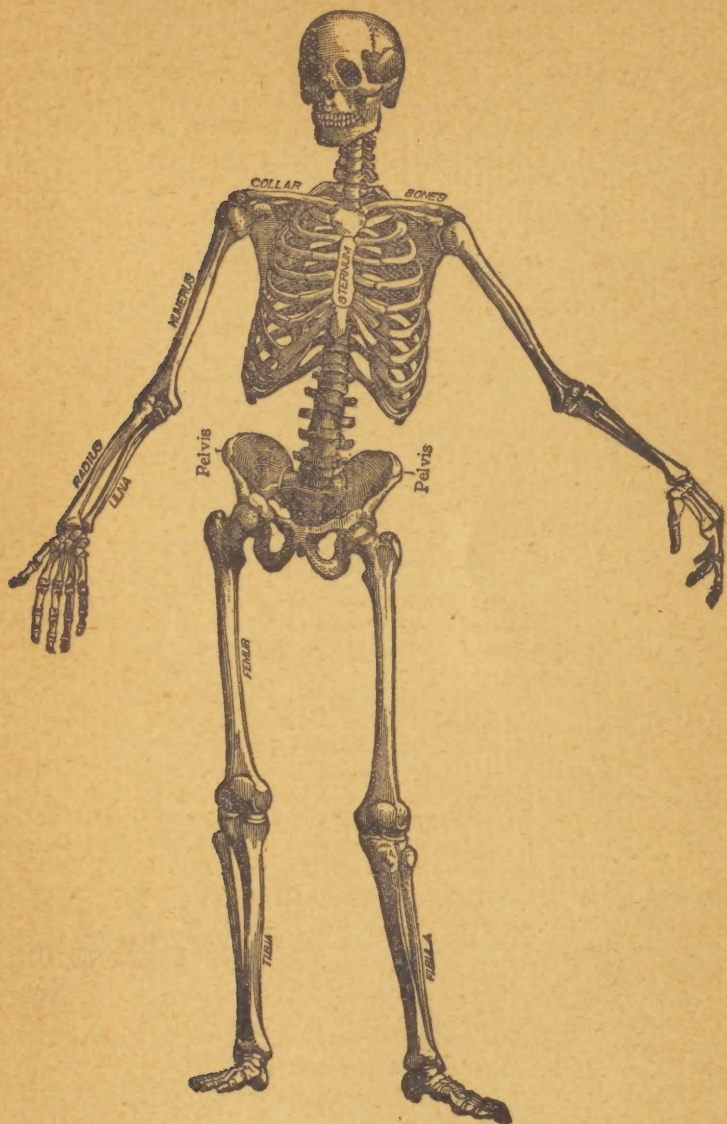
Like many of the great buildings, which are erected nowadays, the body is built upon a firm framework or skeleton. The bones of which this is composed consist mainly of hard mineral matter and partly of soft organic material. Bones like the other tissues of the body have blood vessels, nerves and lymphatics and need them all to be properly nourished. They may be long, short, flat, or irregular, solid as in the foot and wrist, or provided with a cavity filled with marrow like the bones of the leg and arm. A membrane called the periosteum covers bone and gives birth to new cells, which keep up bone life. There are 200 bones in the body, not including the teeth.

Bones are fastened together by strong, firm tissues called ligaments, and these attachments form joints which permit the body to move in different directions, up and down, laterally, and in a circle. Movement between some of the bones is unnecessary and they are comparatively stationary, but between others it is very essential and the joints are so constructed that they can move in any direction that may be required. A substance called cartilage or gristle is placed like a cushion between the bones, at the joints, to protect them from injury during motion.

Over the bones are placed the muscles, layer upon layer, the number of layers and the size of the muscles depending upon the work required of them. Some of the muscles are long and thick, some are short, some cylindrical, some flat, some ribbon-like, all beautifully adapted to the demand that is to be made upon them.

The muscle is covered by a sheath of parchment-like tissue which holds its fibres together and attaches it to other muscles. Many of them also have at each end a thick firm substance called a tendon which holds them in position, gives them an anchorage, and enables them to pull or contract uniformly. Over some of the layers of muscles is placed a dense and very tough membrane called fascia, which protects them and helps their action. On the palm of the hand and the sole of the foot this is especially thick and firm.

Outside the muscles is a layer of fat for protection, for padding in hollow places, for shapeliness of outline, and for service as a non-conductor of heat. Finally comes the skin which covers the entire body and is changed to

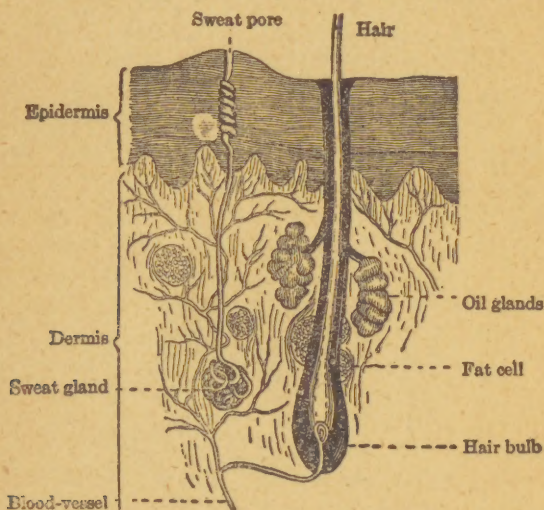


Cut I. The Human Skeleton (Doty)

mucous membrane whenever it approaches an opening of the body. The nose, the mouth, the eyes, are covered with mucous membrane, which is simply an inner skin. The skin is furnished with thousands of little structures or follicles from each of which grows a hair and each follicle has one

or more little glands called sebaceous glands, which supply the hair with an oily substance to prevent it from becoming dry and brittle. Scattered all over the skin are also thousands of little glands, which yield sweat or perspiration, and are extremely important in regulating the temperature of the body. The teeth are also considered an appendage of the skin.

With few exceptions every portion of the body is supplied with blood vessels, of which there are three kinds—arteries, capillaries, and veins. The arteries are stronger and tougher than the veins, while the capillaries are fine and delicate, hairlike in size, and very easily broken. The arterial system begins at the heart, a large vessel called the aorta receiving a charge of blood from the left lower cavity of the heart, as it contracts, and sending it around the body, while another called the pulmonary artery sends, at the same instant, a charge to the lungs from the right lower cavity. Branch arteries are given off from the aorta as it arches over the heart and passes down the side of the backbone. These in turn give off smaller and smaller



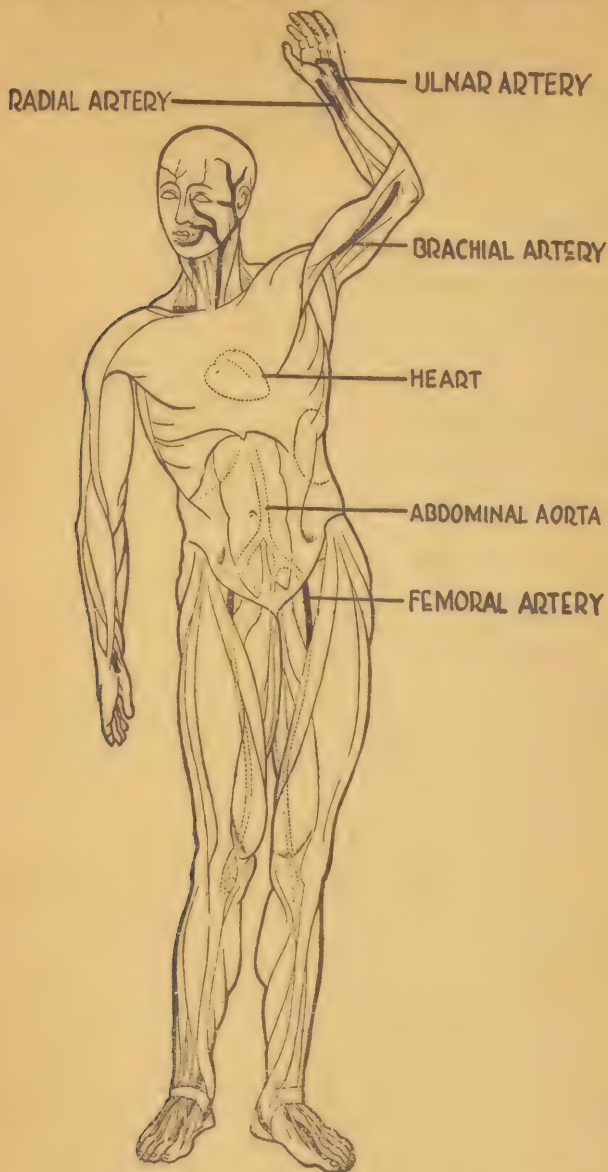
Cut II. Section of Skin Showing Its Different Elements (Doty)

branches, until the entire body has been covered. Then the minute capillaries begin taking up the blood with which the tissues have been moistened by the arteries, passing it to the small veins and these again to larger ones following, in the main, the course of the arteries, but carrying the blood in the opposite direction, that is, toward the heart. Two great veins finally empty it into the right upper cavity of the heart. After going through the lungs discharging its carbonic acid and absorbing oxygen, it again begins its circuit of the body, after passing back to the heart through four veins.

The lymphatics are a series of minute vessels or tubes with structures called glands, somewhat like a bean in appearance, at short intervals, which, accompanying the blood vessels, ever grow larger and larger, and finally end in two good-sized vessels, each of which empties into one of the great veins on the side of the neck. They carry waste and wornout material which they gather from the tissues, and a portion of them carry digested and liquefied food material which has been absorbed from the small intestine.

The nerves are to the body what electric wires are to a building, sup-

plying motion and sensation and even life itself to the tissues. If they are removed or their connection with their centre destroyed paralysis and death follow in the part to which they belong. There are two systems of nerves,



Cut III. Arrangement of Some of the Layers of Muscles, and Course of Some of the Principal Arteries (Doty)

the cerebro-spinal and the sympathetic. The first includes the brain and spinal cord and the branches arising from them. These branches arise in

pairs one on either side of the body. From the brain come twelve pairs which are supplied to the organs of sense, the eyes, nose, mouth, tongue, ears, throat, also the lungs, stomach, larynx, and heart. One of these nerves presides over breathing, and if it were cut or seriously injured breathing and life itself would at once cease.

On either side of the spinal cord arise thirty-one nerves supplying sensation and motion to skin and muscles of the entire body where it is not supplied by the cranial nerves.

The sympathetic system consists of masses of nerve tissue called ganglia, on either side of the spinal cord, with connecting nerves to each other, to the spinal cord, to the great arteries, to the organs of the body, and to other ganglia in the abdominal cavity. They control the nutrition of the organs to which they go, and therefore play a very important part in organic disease. The organs of the body will be considered individually in the chapters which are to follow.

CHAPTER III

THE WORK WHICH THE BODY DOES

Any machine that is good for anything has some kind of product or output, and the larger this product the greater the regularity with which it is yielded; and the better its quality the more valuable the machine. It is of the greatest importance to keep a valuable machine in good condition; it must be kept clean and well oiled, friction and sudden stops and starts must be avoided; it will last longer with careful use than if allowed to remain idle and rust for long periods.

All this is precisely true of the human machine; it has an output we call its work, it must have periods of activity relieved by periods of rest, it must have fuel of the right kind, it must be kept running smoothly; and if this is done and there are no accidents or unexpected mishaps, it ought to remain in good condition at least seventy years, if not longer.

The science that tells us all about these things is called physiology. Physiology, therefore, treats of the relation of different kinds of food to nourishment, of the effect of good and bad air upon the physical condition, the effect of exercise, of sleep, of the different occurrences in mastication, digestion, and assimilation, of the action of the blood, nerves, muscles, and other working portions of the body. In short, it describes the action of all elements of the body in a state of health, in distinction from their action in disease, when they are not doing what they were designed to do.

All these different activities make up what are called the functions of the body—their work. Every part of the body has some work to do; there are no idlers in this hive. Even the much-abused appendix has some part to play in the process of digestion, for it has glands like other parts of the intestinal tract. Because we can get along without it, and it often gives us a lot of trouble, does not prove that we would not be better off if we kept it as long as it behaved properly.

The body is made up of two great classes of materials. Those which in their original form have nothing to do with life are inorganic, like the lime which gives the bones hardness and the salt which we sometimes notice in perspiration. Those which belong only to living beings, to animals or plants are organic, like the albumen in the blood and the muscles, and the fat distributed over many parts of the body.

The most important of the inorganic substances is water, every portion of the body containing it in some form; and if you were to squeeze it out to the very last drop it would represent seven-tenths of the entire body weight.

Other inorganic matter consists of salts of sodium, potassium, lime, and magnesium, and small portions of iron, silica, and fluorine. The most important of these is the sodium chloride, or common salt, which is in all the tissues and fluids, and the lime phosphate, which is most abundant in the bones and teeth, giving them their hardness.

Of the organic substances, the most important are the starches, fats, and proteids or albumenoids. Starch is the product of all vegetable life and is the source of a large part of the food of animal life. It is changed to sugar as a natural process in the vegetables, as in the beet, the sugar cane, the maple tree; and in the animal body as the result of intestinal digestion. Another product of starch resulting from fermentation is alcohol, which is made from rice, potatoes, corn, rye, molasses, etc.

Fat is a vegetable product obtained from nuts and seeds, like almonds, olives, palm seeds, and chocolate, or an animal product deposited in various parts of the body, and is an element in eggs and milk.

Albumenoids or proteids are found in small quantity in vegetables, in large quantity in animals; in fact, nothing except water is so abundant in the human or the animal body as albuminous substances.

Starch is the predominating element in every form of vegetable food, and albumen in every form of animal food, in meat, fish, eggs, and milk. Albumen also is the most abundant organic constituent in the blood.

The organic and inorganic substances found in the body are the substances also by which life is sustained and growth accomplished; we call them foods, and all of them are essential. With the exception of milk, the universal food, no one of them and no one class of them is sufficient to sustain life and produce the best results for an indefinite period.

A great many people eat much more than they require, especially if they have no trouble in getting it. Sugar, tea, coffee, beer, and chocolate often are consumed in excessive quantities, and sooner or later exact the necessary penalty. Food is not appropriated by the body until it has been properly prepared; that is, it must be in a liquid condition and in such a form that it will pass through or be absorbed by a suitable animal membrane.

This preparation is called digestion. It begins in the mouth, is continued in the stomach, and is finished in the small intestine, where that which is suitable is taken up or absorbed by the myriads of little open mouths of the absorbing machinery, transmitted to the blood, and carried by the blood current over the body—where it moistens and nourishes each cell as this is required.

Digestion is accomplished by means of suitable ferments. These are like yeast in the dough, and attack the food mass, split it up, liquefy some of it and pass the remainder along. The food, when taken into the mouth, is cut or torn by the front and side teeth and then ground or pulped by the back teeth—this process being termed mastication. The starchy portion of the food during this process is saturated with the saliva and partly converted into sugar by the ferment it contains.

The masticated food then is forced down into the stomach by the aid of the muscles which control swallowing. There it is churned and rolled about as the stomach contracts upon it, and its albuminous portion is digested by the ferment of the stomach called gastric juice. It is then squeezed and pushed along into the small intestine, where the undigested starches and fats are met and digested by the ferment from the pancreas and bile from the liver. This changes the starch into sugar and makes an absorbable emulsion of the fat. The entire mass is then pushed along, that which is suitable is absorbed and carried by the blood over the body, the residue being propelled into the large intestine and finally discharged from the body.

One of the vital functions of the body is breathing, or respiration. Its object is to get oxygen into the blood and the tissues. No life can continue long without oxygen. Certain forms of bacteria can develop without immediate contact with oxygen, but must get it indirectly. Breathing is accomplished by the expansion and contraction of the lungs. We inhale or take in air, its oxygen is separated from its other elements and dilates the air cells in the lungs. These cells are surrounded by fine blood vessels, through which flows blood which has been travelling over the body.

The oxygen is absorbed through the vessel walls by this blood. Then follows exhalation, when some of the air goes out, and with it the impurities which have been taken out of the blood. The refreshed blood then goes over the body bearing the life-giving oxygen to the tissues.

Another of the functions of the body is to create and radiate heat. When life ceases the temperature of the body drops, perhaps not immediately, but after a time, and with absolute certainty, for the fire is out and cannot be rekindled. The temperature of the adult during health is quite constant, being a little lower at night, when the forces of the body are at rest. The normal temperature during the day is 98.4 degrees F., and it remains so in summer and winter, our clothing being suited to the weather and regulating the radiation of the body heat.

The production of heat is governed by the production of oxygen, by the frequency of respiration, by the process of digestion, and the action of the muscles and organs. Excessive heat is prevented by the perspiration upon the skin, and if this is wanting, or if the action of the sweat glands is shut off, the body temperature may rise to a serious or even fatal degree.

CHAPTER IV

CELLS AND TISSUES

Does it not seem like a flight of the imagination to say that the body is built up from a single cell, and that, when finished, if it were divided into the minutest elements possible, cells only or mainly would be found?

What do we mean by a cell? Those who in former times studied dead tissues from which more or less of the contents had disappeared, leaving only a network or mesh of empty spaces containing air, called these space cells. There is no better illustration of a tissue with its cells than the comb of the honey bee, which is made up of countless units, each containing honey and each a cell fastened to surrounding cells by adhesive material—call it cement or sticking plaster or any other convenient name. Apply that illustration to each separate organ and tissue composing the body and you will get an idea of its cellular construction.

Cells in their relation to the body have been defined as the minute anatomical elements which, with other associated units, make up the structure of the body. Their activities cause the experiences of life displayed by all varieties of animals, and all the structural elements of the animal body are made up by them.

The animal body begins with a single cell called an ovum or egg, less than one-hundredth of an inch in diameter, and out of this is developed one part of the body after another; one form of cell after another, lower grades of cells evolving into higher ones with more important and more extensive functions, as the relations of the growing body with its surroundings become more extensive, until at length the entire complex animal or human body is complete.

An animal cell is a little world, a body in miniature. Its principal part, called the cell body, is composed of protoplasm, which is the simplest form

of living substance we can discover or imagine. No matter about its shape at present. Within, sometimes at one end or pole and sometimes at the other, is a little round or oval mass of matter called the nucleus, and sometimes, if a microscope of high power is used, little bodies called nucleoli can be seen within the nucleus.

The cell body is sometimes uncovered, and at other times a separate covering or sheath called the cell membrane is discoverable. These four elements, then make up an animal cell—cell membrane, cell body, nucleus and nucleolus. Some cells have no cell membrane, and some have no nucleus; the red blood cells, for example. The nucleus differs from the cell body in its structure, its chemical properties, and the work it has to do.

The ovum or egg is one of the largest cells in the body, and some of the red blood cells are the smallest, being only one-fortieth of the size of the egg cell. The protoplasm of the cell body may be homogeneous—that is, of one piece or kind—or it may be made of little specks or granules; and it may have a net work in which the granules or protoplasm is enmeshed.

In addition to the protoplasm there may be minute quantities of coloring matter, fat, crystals, and there may be round, empty spaces or vacuoles. The nucleus is sometimes near the centre of the cell, sometimes at one side, and sometimes at one or the other end, its shape depending upon the activity of the cell. The nucleus may also have fluid within it, like the cells of the honey-comb.

Sometimes cells are soft and sticky, sometimes hard and horny, as in the nails, hair, and skin. When they are dry they are intended merely for protection and not for active work. The shape of cells differs according to their location, their work, and the amount and kind of pressure exerted upon them. The typical shape is probably spheroidal; but as the different parts of the body are developed before birth, they take different shapes for the reasons that have been mentioned, and become cuboidal, spindle-shaped, cylindrical, pyramidal, discoidal, and of various other shapes. The shape which is impressed upon them when the body is being made is retained in most cases during the entire period of life.

It must not be forgotten that the higher forms of cells, like those of the nerves and muscles, are developed out of the lower ones as the body is built up. The higher forms have more extensive functions or work than the lower ones, the principal business of which is to grow and to reproduce other cells. Some of the cells, like the white blood cells and the connective tissue cells, are nourished by bacteria, worn-out tissue, and other substances with which they come in contact, which are grasped and absorbed by them and converted into protoplasm. Being fed in this way or with the fluid food which is the product of digestion, it is supposed they may have a secretion—that is, something of the nature of a juice, which is made by them—or an excretion, which is something they throw off or get rid of, which may cause new chemical formations within them and perhaps cause them to contract and move.

Motion is a distinctive feature of the white blood cells, which roll over and over, and also of the ciliated epithelium cells, which have a plume-like tip on their upper end, waving backward and forward like the feather on a girl's hat. Cells must have oxygen, moisture, and a certain degree of heat as long as they have life. Too much or too little heat will destroy them.

Changes and motion in cells are influenced by chemical, electrical, mechanical, and nervous causes, and their activity may be suspended by dilute acids, quinine, and other drugs. As the body develops in the course of its formation before birth, cells change in their function and activity

from the lower or merely nutritional life to the higher forms which, like the muscle and nerve cells, have special and extensive functions. When a cell is about to reproduce itself the changes are chiefly in the nucleus, which enlarges, throws out fine filaments in all directions, and divides into two nuclei. Then follows a constriction or narrowing in the middle of the cell body, and the one cell becomes two. Very soon this process is repeated, and thus cell life and activity are kept up.

As cells are constantly being born, they are as constantly maturing, wearing out, breaking up, and, being carried away in the blood or lymph stream, undergoing chemical change and finally undergoing elimination by the lungs, skin, or kidneys.

As it is with the cells so is it with the tissues, which are made up of cells packed in layer upon layer, sometimes regularly and sometimes irregularly. A good illustration of these changes is seen in the nails, which are really a part of the skin. They originate from a matrix or root at their base which is constantly throwing cells outward and forward. As they are exposed to air and heat and light they become hard and horny. Each layer of cells is pushed forward by the layer behind it, and when they reach the end of the finger or toe they no longer are needed for protection and are cut off; but unless there be some obstruction the growth from behind continues, cells and horny tissue being constantly renewed as long as life endures.

Those who wish to continue the study of cells will find the works of Prudden and Tyson pleasant and profitable reading on this subject.

CHAPTER V

THE BLOOD

We often hear it stated, and we read in patent medicine advertisements and elsewhere, that the blood is the life. In a certain sense that is true; if you open one of the large arteries and let it spurt a scarlet stream in intermittent jets, in a few minutes the force of the stream will abate, soon thereafter the flow will stop and the person will be dead.

But death might come also without the loss of a drop of blood—by shutting off the supply of air to the lungs, as in drowning, or by paralyzing the brain, by a stroke of lightning, by paralyzing the muscles of respiration as in infantile paralysis, and in many other ways.

Life, therefore, whatever it really is, is controlled in a dozen ways—chiefly through the medium of the heart, lungs, and nervous system.

It is thought also that blood must be up to a certain standard; if it is below that we are apt to say the blood is thin; if above it we say it is too rich. There is something in this, too, for the blood is a complex fluid, and if the proportions of its different ingredients are not what they ought to be the person becomes very pale, or green, or red; becomes deficient in strength and animation and unfit for the hard work and trial of life. He may live, however, for some time with his blood in this imperfect state—restoration to normal conditions gradually taking place, or greater deterioration and death.

The blood in the arteries is scarlet; in the veins it is purple, almost black. The reason is that when the blood comes back from the lungs it has absorbed oxygen from the air inhaled and has given up carbonic dioxide and waste material which are exhaled with air and watery vapor. Scarlet blood goes out from the heart into the arteries, the oxygen in it being carried by the hæmoglobine, which is an element in the red corpuscles. When the blood gets into the capillaries it gives up its oxygen to the cells of the

different tissues which could not live without it, and begins gathering up waste matter and carbonic dioxide, sweeping on into the larger and larger veins on its way back to the heart. The more it gathers of these impurities the darker it becomes, and when it reaches the right upper cavity of the heart it is almost black. It passes into the right lower cavity and then is forced into the lungs for purification.

The blood is composed of two parts—plasma and corpuscles. The plasma is 902 parts water in 1,000 and contains in solution chiefly albumen, mineral salts (the most important being sodium chloride or table salt), and a small quantity of fat. The corpuscles are of two kinds—red and white. The plasma includes 60 per cent. and the corpuscles 40 per cent. of the volume of the blood. The albumen, fat, and mineral salts are absorbed into the blood from the small intestine and are the result of the digestion of food. There is disease when there is too much or too little albumen, fat, or sugar circulating with the blood. When there is a discharge of albumen through the kidneys we may have Bright's disease; when there is sugar we have diabetes. It is of the greatest importance therefore, to have the proper balance of albumen, fat, and other normal constituents in the blood in order to be well and have a good supply of food for the cells of the body.

Sometimes there are parasites in the blood like that which causes the sleeping sickness derived from the tsetse fly, and the bacteria of numerous diseases. The red corpuscles or cells are disc-shaped, of various sizes, stick together like rolls of coin, and are two or three hundred times as numerous as the white ones. They give birth to other red corpuscles, and also are produced from the bone marrow, the spleen, and certain other glands. The most important constituent of the red corpuscles is a coloring material called hæmoglobine. This gives the red color to the blood, but it also has the remarkable property of absorbing oxygen from the air in the lungs and giving it up to the tissues. It contains also iron, being the only part of the body, except the hair which contains this mineral.

Red corpuscles in blood stains are often of great importance in tracing evidence of crime, but are not infallible; for the blood corpuscles in the ape and the dog resemble those in man. The white corpuscles or cells are spheroidal, much larger than the red ones, and as they roll along in the blood current they throw out processes or feelers in what is known as their amœboid movement. They are of the greatest importance to the body. When too numerous they cause a disease called lenkæmia, and, like scavengers, they aid the body by grasping and absorbing bacteria and waste matters and poisons which may come in their way.

The blood does not coagulate or clot in the vessels under normal conditions during life, but it does this after death, as a result of certain kinds of disease, and when a broken blood vessel is tied or otherwise secured. There is a substance within the blood which causes clotting, this process taking place as soon as it is drawn. The longer the clot persists the firmer it becomes, and as it contracts it squeezes out a fluid called blood serum, composed of water, albumen, and salts. The clot is composed of the red and white blood cells and the fibrin, by means of which the clot was produced.

Cold, and neutral salts, will prevent clotting, while heat will encourage it. It is a most valuable arrangement of nature, for it is the natural method of checking hæmorrhage.

In some people the blood does not clot readily, and in such cases when a hæmorrhage occurs it is almost impossible to stop it. I have seen such people almost bleed to death from a very slight injury.

Pressure upon a bleeding vessel favors the formation of a clot, and

that is what happens when a doctor ties a ligature around it, the clot moving backward from the location of the pressure until it reaches the first point where the vessel branches off.

The quantity of blood in the entire body varies in different people, but the average is from 8 to 10 per cent. of the weight of the body; so that if a man weighs 150 pounds he will have from twelve to fifteen pounds of blood. This does not mean that the twelve to fifteen pounds is all in the blood vessels and could be drawn off as you would draw water from a series of pipes; it means the blood in the veins and arteries, plus that in the infinitesimally small capillaries with which almost every portion of the body is supplied.

CHAPTER VI

THE NERVES

Very few people except doctors and those who have made anatomical preparations ever have seen a nerve. In fact, most of the nerves are so small that unless you looked very closely for them and separated them very carefully from the tissues by which they are surrounded you would not notice them. A few, like the sciatic, are of considerable size, and can be easily seen and handled, but the number of this kind is small, while there are thousands too minute to be detected by the unaided vision.

A nerve is essentially a filament or fibre surrounded by a protective substance, and this in turn by a suitable sheath. A larger or smaller bundle of these filaments, secured by adhesive material and protected by a covering, makes a main or trunk nerve—the filaments being distributed as motor nerves or sensory nerves, or both, to the proper tissues, dividing and subdividing so that a great deal of tissue may eventually come under the influence of one trunk nerve. The best comparison I know of is the various wires in an electric cable, which are covered with insulating material held together by suitable means and surrounded with a sheath or covering. These wires are distributed to various parts of a house and are the means for supplying it with electrical energy, for heat, light and power.

Besides the nerve fibre or filament, there is the nerve cell or centre—suggestive of a spider, with its central body and projecting feelers—to which the fibre leads up. The nerve cells are located in little masses or ganglia in different parts of the body, in the spinal cord, and in the brain. The nerve fibres are distributed to every portion of the body; they form lines of communication in the spinal cord and in the brain; they lead up to the centres, where impressions from without are transmuted into ideas.

Nerve substance is of two kinds, called, from their physical appearance, white and gray matter. The nerve fibres are composed of white matter, the cells of gray.

The purpose of nerves is to keep the different parts of the body in relation with each other and with the outside world. They regulate and control the different structures of the body; they are as necessary to the vitality and activity of the different parts of the body as is blood. If the nerve supply of a part is cut off, sensation and the power of motion disappear from that part; it is made helpless, and gradually withers and becomes useless.

The nerves are in every part of the body—in the skin, muscles and organs, and even in the bones. The nerves which go to the skin are almost exclusively for the purpose of sensation, pleasurable or painful or indifferent. Their endings are so close together that two pins could not be stuck into the skin anywhere in immediate contact without producing two separate impressions of pain. The nerves which go to the muscles are for the

purpose of producing muscular contraction, by which means motion of the body is accomplished. There is practically no sensation in the muscles.

The nerves to the various organs of the body in some cases cause sensation and in some cases motion; but their chief function is to regulate nutrition. A nerve may be purely one which causes motion or one which causes sensation; or it may be a mixed nerve and cause both sensation and motion.

There are two nervous systems within the body, the cerebro-spinal and the sympathetic. The former includes the brain and spinal cord and the nerves which proceed from them; it also dominates the sympathetic system, with which it is connected at many points. The sympathetic includes a number of small ganglia in the cavity of the skull, in the neck, the chest, the abdomen, with lines of connection to the brain and spinal cord, to the organs and arteries of the body, and to each other—these lines frequently interlacing and inosculating and forming tangles of fibres called plexuses.

From the brain proceed twelve pairs of nerves, which are distributed to either side of the head and face, to the heart, lungs, stomach, larynx, œsophagus, etc. They are the special nerves of sight, smell, hearing, and they control speech, respiration, the action of the heart, the movements of chewing and swallowing, and the motion of the stomach in the digestive process; hence, they are of the greatest importance in the work of the body, and supply motion and sensation to the eye, face, tongue, and palate. They are composed either of sensory or motor fibres, or both, each kind of fibre preserving its characteristic function in the particular tissue to which it is distributed. The spinal nerves proceed in pairs from either lateral aspect of the spinal cord, thirty-one pairs in all. Each nerve starts from the cord by two roots, an anterior composed of fibres distributed to the muscles, producing muscular contraction and motion, and a posterior distributed to the skin and causing sensation or feeling. The two roots unite soon after leaving the cord and as the compound nerve proceeds on its way it divides and subdivides, the motor fibres going to muscles and the sensory to the skin until the entire area of tissue controlled by each particular nerve has been supplied. Every portion of the body is reached by these nerves from the brain and spinal cord or by their connections with the sympathetic system, and when they are in good working order every part is in sympathy and communication with every other part; they all rejoice or they all suffer together.

The sympathetic nerve system, as already stated, has ganglia, or centres in the head, neck, chest, and abdomen. Within the skull are four pairs of ganglia going to the eyes, ears, salivary glands under the jaw, and the carotid artery, the palate and the nasal mucous membrane. They influence the nutrition and activity of these tissues and organs, and are essential to their vitality. The other sympathetic ganglia are arranged in chain formation on either side of the spinal column, and there is one large ganglion and plexus on one of the great arteries in front of the spinal cord which is well known as the solar plexus.

These ganglia, besides being connected with the spinal cord, send out fibres which are distributed to the arteries, eyes, larynx, trachea, œsophagus, heart, lungs, abdominal organs, etc.

The sympathetic nerves have sensibility and excite motion, but to a lesser degree than the cerebro-spinal nerves. A very important action of the sympathetic nerves, which are distributed to the arteries, especially the smaller ones, is to make them contract when they are stimulated. This is called vaso-motor action, and diminishes the supply of blood passing through them. An example of this is the pallor of the skin, which often

results from a sudden impression of fear, the blood being withdrawn from the arteries which supply the skin and going to the internal organs or elsewhere.

The mode by which impressions are conveyed along the nerves is very interesting. Suppose, for instance, the foot is struck; the impression is carried along the sensory fibres of the proper nerve path until it reaches the spinal cord; it travels up the cord until it reaches the junction of the cord with the brain, then it crosses to the opposite side—from left to right, or right to left, as the case may be—and proceeds to the nerve cells in the brain which are the centre for the part of the foot which was struck. There it is interpreted as a blow upon the foot, and there is a sensation of pain which is referred to the foot. If this is followed by an impulse in the brain centre to kick, the impulse travels down the cord, along the motor fibres of the proper spinal nerves to the muscles which control the movement of kicking. This entire procedure takes only a fraction of a second for its accomplishment.

But impressions do not necessarily go to the brain; they may stop in the spinal cord, which is an independent centre for what is known as reflex action. Suppose, for example, a person is asleep and therefore unconscious; somebody tickles the bottom of his foot; the impression passes up the sensory fibres of the nerve to the proper nerve cell in the spinal cord; it immediately passes back along the motor fibres of the nerve to their distribution in the proper muscles, which contract, and the foot and leg are drawn up—though the individual knows nothing about it.

When a nerve is divided there is a loss of sensation in the skin, to which its sensory fibres are distributed, and in the power of contraction in the muscles to which its motor fibres go. You can prick and cut the skin and there will be no pain and no movement. These parts are then paralyzed and may remain so permanently, with withering or atrophy; or, if the divided ends are not too far apart, they may grow together and the use of the parts be restored. This may take many months, if it occurs at all, or the surgeon may cut down to the ends and stitch them together, and if the operation is successful motion and sensation may return after a few weeks.

Injury or destruction of cells or centres in the brain or spinal cord means paralysis of sensation and motion in the skin and muscles controlled by such cells. It is because of this destruction that those who suffer from infantile spinal paralysis have withered and helpless muscles; and if the muscles are restored it means that the cells were not destroyed, and have recovered from their injury.

CHAPTER VII

THE BRAIN AND SPINAL CORD

The brain and spinal cord should be considered together, because they are immediately connected with each other, and without the spinal cord messages from the brain could not be sent out over the body.

If the spinal cord be completely divided there is absolute paralysis of motion and sensation below the line of division. Notwithstanding this paralysis and helplessness the organs of the body may continue working, supplying nutrition and carrying off waste, and the brain may be more or less active for an indefinite period—perhaps for many years—before this half life is finally arrested.

Along different portions of the spinal cord impressions or impulses received at the surface of the body and carried to the cord by the proper

nerves are conveyed to the portions of the brain which are adapted to receive them; the line of communication crossing to the opposite side of the body at the junction of the brain and the cord.

These impulses are interpreted at once by the brain and transformed to outgoing impulses which pass down the cord, thence along the proper



Cut IV. Brain, Spinal Cord, Spinal Nerves and Their Distribution (Doty)

nerves which spring from the cord, to the muscles to which these nerves are distributed, culminating in contraction of the muscles and motion of the portion of the body controlled by these muscles

Other impulses which result in motion may originate in the brain by means of the exercise of the will, these being called voluntary impulses.

The nerve cells in the spinal cord also are centres for what is known as reflex action, impressions from without being received by them and transformed into impulses which result in motion without going to the brain at all, and even without consciousness that the motion is taking place. The automatic actions of the body movement during sleep, and motion in other conditions of unconsciousness are of this character.

The spinal cord, therefore, is concerned in motions which are made for the protection of the body, and in the balancing motions in attitude and gait. The awkward gait in locomotor ataxia is due to the want of co-ordinating power in the action of the various muscles which are used in walking, owing to disease in the spinal cord.

In the spinal cord also are the nerve centres which preside over the control of the bowels and bladder, and when these centres are diseased or injured control over their function is lost, thus adding to the helplessness and misery from which the patient is suffering.

Finally, the arrangement of the gray and white matter in the cord is the reverse of that in the brain, the gray matter with the nerve cells being within in the cord, and without in the brain.

The brain is a very complex and wonderful organ. Its upper four-fifths are occupied by two large masses called the hemispheres or cerebrum. Beneath the posterior portion of the hemispheres is the cerebellum, or little brain. Below the hemispheres in front of the cerebellum are important masses of gray matter called the cerebral ganglia, and between the spinal cord and the cerebellum, like an isthmus, is a small but vitally important mass of gray and white matter called the medulla oblongata. The fibres of white matter of the cord pass through the medulla oblongata into the brain, connecting the different portions of the brain with each other and with the cord.

The hemispheres and the cerebellum are symmetrically divided in the middle, and each has a layer of gray matter, of varying thickness in different cases, on the outside, and white matter within. The arrangement of the gray matter is in loops or convolutions, and the different portions of the hemispheres are divided off by splits or fissures, this arrangement permitting the concentration of an enormous number of nerve cells or nerve centres.

The hemispheres of the brain form the organ of intelligence or thought, and it seems to be the number of nerve cells quite as much as their quality which determines the capacity of a brain; at any rate, the brains of men who have been distinguished in the world of thought have been almost invariably larger and heavier than those of ordinary individuals.

Just how an impression from without is transmuted into an idea, just how a nerve centre is stirred to produce a thought or a train of thought, I do not know—and I doubt if anybody else knows. Perhaps it is one of those elusive things nobody ever will catch and hold on to. If the hemispheres are carefully removed from certain animals it does not kill them, but they become apathetic and apparently unable to start any line of action such as they have been accustomed to.

Men in war and in civil life who have lost considerable portions of the hemispheres have lived for long periods afterward, and have been able to gain a living; so it is difficult to say just how much brain substance is necessary for human life and for the performance of its ordinary duties. Idiots do not usually have brains of any considerable size or weight; and, what is very significant, the convolutions or loops are flat and lack depth and size, though there may be the number usually found in the ordinary type of human brain.

Investigations with human beings show that in the hemispheres are the centres of memory, reason, and judgment, these being all absent or merely rudimentary in those who are idiots from birth.

It has been clearly determined that certain points in the hemispheres are centres for certain acts—particularly for motion, sensation, sight, and language. For instance, a person has a slight hæmorrhage in the frontal convolution of the left hemisphere. The pressure of this blood upon the centre for speech may destroy his ability to talk distinctly and limit his vocabulary to three or four words. If the hæmorrhage is more extensive he will be unable to move his right arm, and if still more extensive the whole right side and both upper and lower extremities will be completely paralyzed. Or, if the skull is opened over the left frontal convolution and a galvanic current is passed through a minute portion of it the person thus treated will utter a cry though he may be completely unconscious.

If there is disease or injury in the white matter of one of the hemispheres there may be loss of sensation on the opposite side of the body without loss of motion. The cerebellum is a far less important portion of the brain than the cerebrum. It has communication with both the cerebrum and the medulla, and there may be more or less interaction between these different parts. It has no power of influence over sensation or motion near its surface, but deeply within, in the vicinity of the medulla, it has both. Its injury or destruction has no influence upon the senses or the intelligence, and it does not cause loss of power or motion, but it does deprive one of the power of co-ordinating movements and causes him to stagger like a drunken man in his efforts at walking.

The medulla oblongata, as already stated, is the continuation of the spinal cord and has its immergence into the brain. From it originate most of the nerves called the cranial nerves. From the pneumo-gastric nerve, which originates in the medulla, arises its power over respiration, and if the medulla is seriously injured respiration at once ceases. Hæmorrhage in or near it would consequently result in arrest of respiration and immediate death. It also controls the movements of swallowing and of ordinary speech and articulation through its action on the vocal cords, which are the essential parts of the glottis, which is the organ of the voice.

The muscular action by which food is carried down the tube which leads from the mouth to the stomach, and some of the muscular movements in connection with respiration, are reflex actions not controlled by the will. are under the influence of the medulla oblongata and are essential to life; hence interference with them by injury to the medulla means serious or fatal results, and emphasizes the importance of the bearing which this small organ has upon the citadel of life itself.

CHAPTER VIII

SLEEP

Consideration of this subject includes not only normal sleep, such as comes to those who are in every way in good physical condition, but the various digressions and aberrations from the normal that result from injury or disease, occupation or bad habits, or the influence of poison.

It is difficult to define sleep with exactness. Many have tried it, but I have failed to see a definition which is entirely inclusive and comprehensive. The reason of this may be that the cause of sleep is not the same for all persons, nor the same for one person all the time. At any rate sleep, that is real sleep, is unconsciousness. It is not necessarily

profound, for light sleepers waken with the slightest disturbance sometimes even from the mere presence of another person near them.

On the other hand, sleep is often so deep and stupefying that it resembles the unconsciousness of coma when the brain is paralyzed by injury or disease. Though unconsciousness exists in normal sleep and the brain is inactive, the nutrient forces of the body go on, even if at lesser speed than in waking and working hours. The heart and lungs particularly are required to keep on without pause or respite; but the digestive, the urinary, and the reproductive apparatus are doing only moderate work—are on half-time, as it were.

Inasmuch as we know that anæmia of the brain will cause unconsciousness, it seems to me that this must be the principal factor in producing sleep, and since the influence of many poisons—not only drugs, but other substances which may circulate in the blood—is seen in the drowsiness, stupor, lethargy, and unconsciousness which follow their use, it is fair to presume that the waste substance of the body, especially the urea, the poisonous matter absorbed from the intestines and bladder, and the material generated by the excessive work of muscular tissue of various kinds which gives us the feeling that we call fatigue are all contributing factors in producing sleep.

The entire muscular system is quiescent; this is vividly demonstrated in the disease known as paralysis agitans, or shaking palsy, in which certain muscles are constantly in action during the waking hours, but during sleep are at rest.

Rest for the muscles is essential to life. The human machine does not differ from any other in this respect; if it is worked continuously it soon wears out. Many people who say they are poor sleepers do not appear to suffer severely from this fact, for they lie quietly in bed for a sufficient number of hours and learn to be passive and to free themselves from brain activity, even though they may not enjoy the great boon of peaceful, continuous sleep, hour after hour.

That the brain is anæmic during sleep is at least suggested by the loss of color in the face, which occurs in many, though not in all, people, as the heart slows down and the blood tends to accumulate on the venous side of the circulation.

The object of sleep is recuperation, renewal, renovation.

“Who, upfurled beneath thy drowsy wing a triple hour,
But renovates, and lives?”

It is the relaxation of the tension of muscles, the rest of brain and nerve cells; like the yielding of a rubber band before renewed stretching, or the interval of rest in an electrical battery in order to store up strength and energy. It has often seemed to me more important than food. Some people have gone three or four weeks without food. Very few could go three or four weeks without sleep; most of us are not of much use if we pass forty-eight hours without it. I have read of but one case in which it was stated with apparent truthfulness that a certain man never slept, and as he was in a hospital, watched day and night, and seemed not at all the worse for his vigil, it may have been true—but it is certainly against nature.

Nature has arranged that the requirement of sleep should vary for different persons and at different periods of life. An infant sleeps almost continuously. For infants and growing children many hours of sleep are indispensable to healthy development. In mature life one-third of the twenty-four hours passed in sleep satisfies the requirements of most people, women frequently getting along with fewer hours than men. In

old age there are many who say they are satisfied if they can sleep four or five hours, but in my experience this rule is by no means general, and I believe there are many who return to the conditions of childhood and sleep the larger part of the time.

The influence of sleep in conserving vital force is well illustrated in the case of hibernating animals, who furnish sufficient fuel from their own tissues to keep their machinery in operation several months.

The custom in tropical countries of sleeping after the mid-day meal is a good one, and might well be followed in temperate climates, especially during the summer months.

Night seems to be better adapted for sleeping than the day—partly on account of the darkness, principally because of the force of habit. The insane, the neurotic and neurasthenic, patients with acute diseases, and brain workers often suffer from loss of sleep; and the period of life when sleep is mostly likely to be irregular is between thirty and fifty.

People can usually adapt themselves to sleeping at any time; and, indeed, there are many ways in which compensation takes place when it becomes necessary to change the customary scheme for performing natural functions; but I think it is a hopeless task to attempt to improve upon the methods of nature, and that violations of natural conditions must be paid for in some way.

The season of the year has more or less to do with sleeping, in many instances; some sleeping better in summer than in winter, while with others the reverse is the case. Altitude and atmospheric pressure have a very distinct influence upon sleeping in many cases; those who are accustomed to sleep at the sea level finding great difficulty in sleeping at the diminished pressure of two or three thousand feet. On the other hand, people with pulmonary diseases who cannot sleep well at the sea level are often greatly relieved by removing to a moderate elevation.

Sleep not only may be insufficient—insomnia, we are accustomed to call it—but it may have irregular forms and phenomena, including dreams, nightmare, night terrors, somnambulism, trance, epilepsy, lethargy, hypnotism, sleep due to poisons, and the African sleeping sickness.

When one dreams the sleep is usually light, perhaps towards the end of a period, and one often awakens at the end of the dream. The more intense and vivid the dream, the more likely will it be to awaken the sleeper. It implies a certain amount of brain action; it does not necessarily imply a vigorous brain. Children's dreams are often exceedingly intense, and when fearful and with nightmare, we call them night terrors.

Nightmare at any age is often the result of disease of the heart or liver, or of overeating, or poor digestion; hard work being required of organs which should be quiescent. Irregularities in sleep often seem to be inherited, particularly in those whose parents have had a bad nervous system. Lying on the back disturbs sleep in many cases, and the same is true if the head is too high or too low, or if the bed clothing is too heavy or too light.

Drowsiness or lethargy often makes it impossible for one to remain awake, particularly if one tries to concentrate attention in church, in the theatre, or in any public gathering where the air is poor and the lights brilliant. The inclination is often overpowering and one may fall asleep standing or at work or in any kind of employment. Such people may sleep many hours at a time. Sometimes it is due to disease and sometimes it is merely an individual peculiarity.

In somnambulism there are sleep and unconsciousness; the walking and other actions are automatic and without volition or brain activity; but it

is such a bad and dangerous habit, whether in the young or the old, that it ought to be brought under control.

Hypnotism, trance, or mesmerism is a form of induced sleep, particularly by suggestion, and often with those whose wills are weak. There are occasions when, it seems to me, they may be of service; but they are edged tools and should not be used indiscriminately.

I am inclined to think that, like mental science, Christian Science and other more or less popular cults they have a field of usefulness, though not a large one. I do not believe in wholesale condemnation of these things merely because somebody may have been hurt by them.

CHAPTER IX

THE SENSES

Intimately associated with the nervous system, and dependent upon it for their activity and keenness, are those five properties or endowments called the senses, by which animals come into contact and relation with the world which is external and exterior to them.

The inorganic world is without senses or sensitiveness because it has no life. Life, therefore, is a fundamental condition of the manifestation of the senses. Plants have the sense of feeling—at least, many of them have—and it would seem as if some of them have taste and hearing; although they certainly have no distinctly developed organs corresponding to the sense organs of animals. The senses in the lower grades of animals, taken as a whole, are less highly developed than in the higher ones. They may lack organs for certain senses, especially for hearing, seeing, and smelling; but those senses which they have are sufficiently developed and acute to enable them to gather their food and furnish defense and protection of a more or less effective character against their enemies.

In those animals which are most highly developed—including man, of course—there are sense organs by which feeling, taste, smell, sight, and hearing become possible and are regulated.

General sensation, or the sense of touch, is the most widely distributed of all the senses, and is present wherever life is found. In animals it is manifested through the medium of the skin and the mucous membrane which lines certain cavities of the body and corresponds internally to the skin. In every infinitesimal portion of this great extent of surface are the terminals of sensory nerves, the main trunks of which originate in the brain for the head and face, and in the spinal cord for the rest of the body.

The first impression which comes with this sense is that of contact; we are touching something or something is touching us.

Next we derive a sense of the quality of the object touched—hard or soft, rough or smooth, large or small. Then comes the sense of temperature; the skin becomes cold or hot; then the sense of pain or its opposite extreme, want of sensation or anæsthesia. Both pain and anæsthesia may differ in degree, and pain may be caused by mechanical injury or violence, or by extreme heat or cold.

It is interesting to note the short interval which separates sensations of pleasure from those of pain, and again from those of complete anæsthesia; and how, under certain conditions, one seems almost converted into the other. The way we become conscious of feeling is that an impression received upon the skin travels from the surface along the track of a nerve until it reaches the spinal cord; then it goes upward along the proper part of the cord, crossing to the opposite side where the cord

joins the brain; then going to the proper nerve cell or centre in the brain, which interprets the impression to the consciousness.

Closely connected with the sense of touch is taste—and, indeed, it may be a part of it. The organ of taste is mainly the tongue, but not exclusively, for taste is not abolished when the tongue is removed, as it frequently is when the seat of disease. In such cases more or less acute sensitiveness of taste may still remain in the mucous membrane of the mouth, and in cases in which there is a flavor or aroma to the food it is appreciated also by the mucous membrane of the nose. The tip of the tongue is the portion which is most sensitive to taste and flavors; but its entire surface is capable of receiving such sensations.

Flavors are most keenly appreciated when the substances are in solution. A dry, hard, or heavily coated tongue is incapable of fine distinctions, and perhaps this is the reason why a clean, moist tongue has been considered an important indication of health from time immemorial. It is certainly true that the sense of taste is blunted in those diseases in which the mucous membrane of the mouth is affected. The impressions which are received in the mouth and tongue are carried by the proper nerve directly to the nerve centre in the brain, and there are translated into their proper significance.

Impressions of odors are received upon the terminals of the olfactory nerves in the mucous membrane of the nose, and are carried back to the origin of the nerves through ganglia or nerve centres lying under the brain.

In those animals in which the sense of smell is very acute, these nerve centres are more highly developed than in man.

It sometimes happens that persons are born without any power of distinguishing odors and smells; and if in these cases the nerve centres are wanting it would be quite impossible to develop the sense of smell.

The most remarkable and the most important of all the senses is sight, and the apparatus by which vision is accomplished is one of the most interesting in the entire mechanism of the body. It is the chief means by which most men are enabled to get their living, and there is no more beautiful and beneficent work than that which teaches the blind to occupy themselves in various useful ways to overcome their dependence and to solace their darkness.

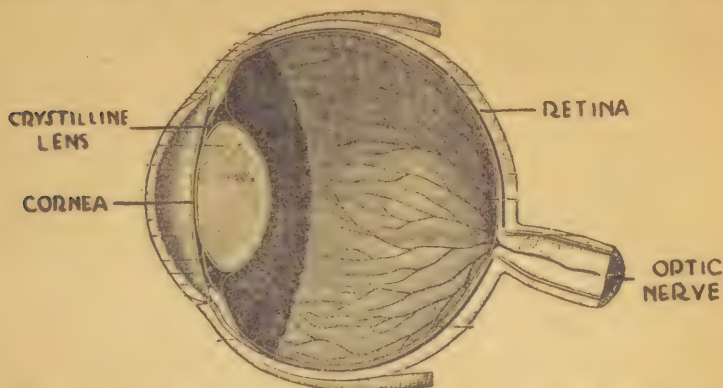
Vision gives us not only sense of light and shadow, but permits us to distinguish color and to adjust our visual organs with great rapidity to the most remote as well as the nearest objects.

The visual apparatus is more complicated and intricate than that of any other of the senses. The eyeball is a spheroidal fibrous sac with two chambers—the anterior of which contains a clear watery fluid and the posterior a viscid gelatinous one; between them, suitably attached, being a double-convex, crystalline lens. In the front of the eyeball is a transparent glass-like convex segment of a sphere called the cornea, while just in front of the lens is a muscular contractile curtain or diaphragm, called the iris, with a central perforation or pupil, and containing pigment which gives to the eye its color. The posterior chamber is lined by a very remarkable membrane called the retina.

The eyeball is moved about by a series of muscles which are suitably attached to it to permit motion in all directions. The retina may be regarded as the expansion of the optic nerve, which enters the eyeball from the rear after arising from several sources in the brain and passing through the optic ganglia or nerve centres.

The retina is not only a complex arrangement of nerves and cells and nuclei, but it is a membrane which is specially adapted for the reception of

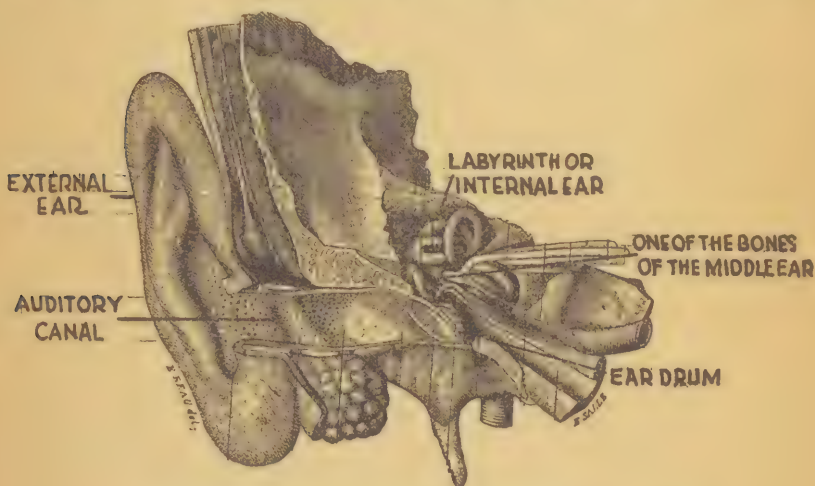
light rays and is connected by fibres of the optic nerve with the central parts of the brain. When a ray of light strikes the eye it passes through the cornea, the fluid of the anterior chamber, the lens, and the fluid of the posterior chamber to the retina; this excites the fibres of the optic nerve by



Cut V. Vertical Section Through the Globe of the Eye (Sappey)

which the impression is carried to the proper part of the brain and interpreted.

The peculiar structure of the eye enables us to accommodate vision for objects at different distances, the iris, the lens, and certain muscles undergoing suitable changes until the object of vision is clear and distinct. As the shape of the eyeball changes, in near sight and far sight, art comes



Cut VI. Principal Structures of the Ear (Sappey)

in and, by the application of suitable lenses or glasses, remedies the defects of nature.

The sense of hearing gives us impressions of sound or sonorous vibrations with their varying qualities, and aids us in the determination of time.

In the organ of hearing there is a trumpet-shaped outer part which gathers the vibrations and a tube which conducts them to a vibrating membrane. Attached to the inner side of this membrane is a small bone communicating in succession with two other small bones—this chain of bones being in a small chamber called the middle ear. This chain of bones conveys the vibrations to a complicated structure called the internal ear, or labyrinth, within which is the vast number of minute ends of the auditory nerve. This nerve carries the auditory impressions to the brain, and there they are translated into their different meanings.

Of course, the different impressions which are received by the senses are recorded and interpreted with great rapidity. If it were not so it would be impossible to accomplish the work which is constantly being done through their assistance. We can appreciate this when we realize how slow and imperfect our work is when we are handicapped by the injury or destruction of any of the organs through which this work is performed. This fact ought to lead us to conserve all these organs by every possible means, especially by correct modes of living.

If we are fortunate enough to be endowed by nature with well developed organs of sense it will be principally our own fault if they do not serve us well until, like every other machine, they are worn out by long continued use.

CHAPTER X

GLANDS AND THE GLANDULAR SYSTEM

About the only varieties of glands with which people in general are acquainted are those in the neck which become infected and enlarged from tuberculosis, frequently suppurate and become running sores, and are distinctly a mark of poor nutrition—especially in children, with whom they are frequently present, and the glands in the groin, which also are frequently enlarged as a result of infection from various sources. These are lymphatic glands—part of the lymphatic system which already has been briefly described. But though the lymphatic system is co-extensive with the tissues of the body and the lymphatic glands are most numerous of all the glands, they form only a part of the entire glandular system.

The structure of glands differs according to the work they have to do; it may be very simple or it may be very complex. The structure of lymphatic glands is simple: an outer capsule, from the inner side of which partitions project and converge toward a centre, making a framework in which is collected the pulp or tissue proper of the gland, a set of lymphatic vessels bringing lymph to the gland and another carrying it away, with more or fewer lymph globules which are made within the gland, and a blood-vessel system of arteries, veins, and capillaries like all organized structures.

The structure of the liver and the kidneys, on the other hand, is complex in the extreme; and though the liver has been carefully and methodically studied for many years by the most skilful and astute physiologists and anatomists it is doubtful whether its complete function is yet entirely understood.

Primarily a gland is an organ or a structure which makes or secretes something, and the glandular system is like a series of factories, each having its own peculiar output, large or small, essential or less essential.

The more we learn about the work of the different parts of the body the more we find the importance of each to the other in making up a complete and normal individual; and though it is true we can do without

certain parts and sometimes entire organs, the body becomes defective by just this loss. I never have been able to convince myself that any organ of the body was superfluous or unnecessary.

A very important subdivision of glands is into those which have ducts or outlets and those which are ductless. If a gland has an outlet the product of the gland flows through it to its destination, just as water flows from a spring into a brook, which is its outlet. But if a gland has no outlet the only way its product can escape and do its work in the body is by being absorbed into the blood current and carried by that great express company to its destination. The liver, the pancreas, the salivary glands, all are examples of glands which have a duct. The lymphatics, the thyroid, the spleen, the pituitary body, the supra-renal capsules are all glands which have no duct and consequently must depend upon the blood current to carry off their product.

What are the different glands of the body and what is their function? I have already referred to the lymphatic glands through which the lymph stream is poured and possibly changed in some way, either chemically or mechanically, and also the lymphatic globules or corpuscles, which are generated in them and carried into the blood current to become transformed into white blood corpuscles.

Within the abdominal cavity are glands of the greatest importance, for they control the digestion and absorption of food—which is to the body what fuel is to the furnace, the source of heat and energy. These glands are the liver, pancreas, spleen, and myriads of very minute but very important glands in the stomach and intestines. They secrete the juices and ferments which convert the starches, fats, and proteids which have found their way into the stomach and intestines into an absorbable fluid which is taken up by the absorbents of the small intestine, transferred to the blood, and then conveyed to all portions of the body.

The glands of the large intestine prepare the residue of food which has not been absorbed for its elimination and discharge from the body, to which it is of no further use.

The kidneys are often called glands, but are not so in the sense that they manufacture a secretion. They excrete urine from the blood as it flows through the intricate system of tubules or filtering apparatus with which each normal kidney is provided.

The spleen has a secretion, but it has no duct, its secretion being taken directly into the blood. One of its most important functions is to supply in part the red corpuscles of the blood.

The genital and urinary apparatus of the body is abundantly supplied with glands which furnish the secretions necessary for the performance of its physiological functions.

The mammary glands are the essential organs by which the secretion of milk is provided. Though this is commonly understood to be an accompaniment of pregnancy and the period which follows child-birth, this is not the case exclusively, for these glands may secrete fluid at any period from birth to old age. It is even possible for the mammary glands in men to be functionally active and secrete milk. The joints are provided with glands which secrete synovial fluid for their lubrication. In the mouth the large salivary glands furnish sufficient quantities of saliva for the moistening of the mucous membrane and the food which passes through the mouth. The saliva not only moistens the food, but it contains a ferment which begins the digestion of starchy foods. The mucous membrane of the mouth, cheeks, tongue, and lips is studded with minute glands which assist the salivary glands in keeping it moist at all times. The wax which accumu-

lates in the ears is a glandular product; also the tears which flow from the eyes.

The entire area of the skin is covered with glands, one set called sebaceous glands, being associated with the hairs and providing them with lubricating material, which seems to be a very important function in the glands of the body, and another set called sweat glands, being constantly busy in furnishing moisture to the surface and thus regulating the temperature of the body.

The material from which the glands produce their secretion is the blood in their capillary blood vessels. This blood comes in contact with the epithelial cells of the glands, and each minute cell takes from it its infinitesimal requirement. After undergoing the necessary chemical change in the cell the product joins that of countless other cells, finding its way to the duct of the gland and then being either poured out or absorbed into the circulation.

A gland may be so small that it is invisible to the naked eye, and a simple tube in its structure, or it may be as large as the liver, which in the normal adult weighs at least four pounds.

The glandular system gives one a slight idea of the wonderfully complicated arrangement of the structure and chemistry of the body.

CHAPTER XI

THE SKIN*

Most people probably would be surprised to learn that the skin is essential to life. Of course, not every particle of it; and when certain parts are lost they can be restored by grafting bits or islands of sterilized skin from other portions of the body or from the body of some other person. But if the entire skin were taken off, or even very large portions of it, the person thus deprived would surely die.

Extensive burns of the skin are usually fatal. If the victim recovers it is with disfiguring scars, perhaps, in spite of any attempts at grafting, and the injuries he suffered may condemn him to a life of torture. I have seen children afflicted in this way, and very pitiable objects they were.

Again, if the skin were covered with an impermeable varnish or a person were buried in the earth up to the neck, that person would die from suffocation, the skin being in a certain sense supplementary to the lungs in the important function of respiration.

Every portion of the body is covered with skin, and it is as highly organized as any other organ of this wonderful machine we call the human body.

We have been considering the various systems of nerves, glands, lymphatics, and blood vessels with which the body is provided. The skin is provided with all of them, and very abundantly too; and that is why it responds so readily to heat and cold, pleasure and pain, fatigue, exhilaration, and various other impressions.

One of the first things we note in regard to the skin is its color; it may be white or black or red or yellow. This is because of the pigment or coloring matter in the cells upon and just beneath the surface of the skin, which are being constantly renewed and as constantly shed. Snakes and some other animals have the advantage of shedding this outer skin all at once at certain periods in their lives.

It seems foolish and unscientific to form our estimate of men principally from the color of their skin, yet that is the basis of judgment of a great many people, especially in this country.

* For cut showing the structure of the skin, see page 6.

Besides this outer horny layer or epidermis which is constantly wearing out there is a soft inner layer always containing more or less fat, which, when taken from animals and subjected to the process of tanning, we call leather. In this inner layer mainly are the different structures which make the skin an organized portion of the body—namely, nerves, veins, arteries, muscles, lymphatics, hairs, and hair follicles, sebaceous and sweat glands, and nails.

Primarily the skin is the covering which protects the inner structures of the body, particularly the organs by which the functions relating to its nutrition, are carried on. It is an excellent non-conductor, so that no matter what the degree of atmospheric temperature may be the interior of the body is so protected that, when in health, its temperature is uniform at about 98.4 degrees F.

Almost as important as its protecting function is the fact that it is the seat of the sense of touch. This sense resides principally in the endings of those sensory nerves which are distributed to the skin. Upon the hands and feet, where the sense of touch is particularly acute, and to a lesser extent in other portions of the body, the nerves terminate in a peculiar bulbous structure, which seems to have the power of intensifying the touch sense. These bulbs form a series of figures of infinite variation upon the finger tips, and the impressions made by them are the basis of an indelible record in the identification of criminals and others.

This sense is so generally distributed that it would be impossible to prick the body in two places, no matter how close together, without feeling the sensation of pain in both of them.

The importance of the sense of touch can best be appreciated by those who have had it and lost it by paralysis or some other disease or accident. To be unable to appreciate pain might be considered by some a great boon; but it is different if at the same time there is complete loss of all the other sensations which we appreciate through the skin.

The muscular supply of the skin is meagre, but is better developed in some individuals than in others, while in some of the animals it is very abundant. Around the eyes and in the external ears of some people there are sufficient muscle fibres to enable them to move the skin, and at the root of the hairs there are often muscular fibers which, under certain influences, cause the hair to stand on end.

One of the most important functions of the skin is that which is connected with the sweat glands. These are tiny coiled tubes lying deeply within it and extending to the surface, of simple structure but supplied with nerves and blood vessels, and one of the important means by which the waste matters of the body are eliminated and the work of the kidneys and intestines supplemented.

They discharge this material with the sweat which is ever forming, and which, under ordinary circumstances, in the form of insensible perspiration is not noticed. Under the influence of emotion and various forms of nervous excitement, muscular exercise, and high atmospheric temperature the activity of these glands is increased. It is estimated that as many as 2,400,000 of them are distributed over the entire area of the skin and that they discharge as their secretion two pints or more of fluid daily in the average adult. This has a decided influence in maintaining the balance of temperature of the body and is greatly missed when the body is sick or dry from fever or other causes.

The hairs develop from a matrix in a very simple gland or follicle in the skin, nourished by blood vessels and nerves. The hair has a terminal bulb from which the cells of which it is composed, as they grow, are pushed forward—forming the hair which, when it is completed, consists

of root, shaft and point, and may cease growing at a certain limit or continue indefinitely.

Like some other portions of the body it contains pigment by which its color is determined. It appears in greater or less abundance on all parts of the body excepting the palms of the hands and the soles of the feet. Near the point of emergence of each hair from the skin are one, and sometimes two, small structures called sebaceous glands, which secrete an oily substance for the lubrication of the hair. Frequently this material is excessive, making the hair very greasy—appearing in the form of dandruff and often loosening the hair and causing it to fall out.

The nail is similar in cellular structure to the hair, and grows in a specially provided groove from a matrix or root; the cells, as they grow, ever pressing forward those which are ahead of them. When they reach the free surface at the end of the finger they are worn or broken or cut off, unless they are nourished and cultivated to unusual length, as is the habit in some nations.

The mucous membrane which lines certain cavities and hollow organs of the body is in structure quite similar to the skin. Its external layer is softer and more moist because its function is different from that of the external layer of the skin.

CHAPTER XII

THE LYMPHATIC SYSTEM

The average individual would be unable to tell you what is meant by the lymphatic system or what is its importance in the functions of the body. Nevertheless, it plays a very important part in the machinery and the work of every human being. It consists of innumerable minute, small, and moderate-sized tubes, built on the same general plan as the veins, arranged sometimes in mesh work, sometimes in lines, and sometimes irregularly, with structures known as glands—about which something has been said in another place—intercalated or inserted at short intervals, like the glass insulators on telegraph poles.

The blood vessels form a system which works from the heart, or centre, through the arteries and capillaries to the veins, or periphery, and then back again to the heart. The lymphatic system, on the contrary, begins at the periphery—that is, at the skin and mucous membrane—and passes inward toward the centre. There are superficial and deep lymphatics located in the skin and mucous membrane, the connective tissue and muscles, the bones, and the various internal organs. Beginning as tubes of infinitesimal size, or even as mere spaces without any definite structure, they become larger and larger as they approach the centre from either side of the body and limbs, and finally form a trunk vessel on either side which passes upward to the neck, joins one of the great veins on that side, and into it empties its contents—which thus become a portion of the blood, which is speedily conveyed to the heart, thence to the lungs to be relieved of its impurities and revived with oxygen for the recurrent circuit of the body.

The lymphatic system, therefore, is contributory or complementary to the veins.

Of what do the contents of the lymphatic vessels consist?

Under ordinary conditions they consist of lymph, a transparent, amber fluid similar in its constituency to the plasma of the blood, and therefore quite suitable to be incorporated into the blood current. After the food has been digested and fluidified and its current has reached the second of the three parts into which the small intestine is divided, it bathes myriads

of little structures in the intestinal mucous membrane, called lacteals or villi or absorbents. These are a portion of the lymphatic system, the fluid they absorb is rich in fat, which gives it a whitish, milk-like appearance, and it is called chyle.

Entering the lymph stream during the hours of digestion, it thus transforms this during those hours from a transparent to an opaque, milky fluid.

The lymph is composed of water, fibrinogen—which gives it coagulating power, as it does the blood—mineral salts, albumen, and fats. There is less albumen in the lymph than there is in the blood, and it is more or less in the form of waste or used-up material. The fat which is contained in the chyle is an important contribution to the blood.

The lymph also contains bodies called lymph globules or lymphocytes, which are derived from the lymphatic glands and are developed in the blood stream into white blood corpuscles.

The lymph vessels are located in close relation with the blood vessels; wherever one is, the other will be found. Their relations with the capillary blood-vessels are especially close and important. The capillaries are arranged in meshwork throughout the tissues and organs of the body. A meshwork of lymphatic capillaries corresponds to and is associated with each meshwork of capillary blood vessels, so that there is a space, varying in dimensions, containing some kind of tissue between them.

Into these spaces, the tissue in which is made up of cells, through the more or less porous capillary wall the blood passes, moistening the tissue as the water of a stream moistens and is absorbed by the soil along its banks. The constituents of the blood—its water, its albumen and fat, its mineral salts—nourish and sustain the cells with which they come in contact, and that is the way the cells which form the minute structure of the entire body are maintained. Of course, cells are being constantly worn out and disintegrated, their places being taken by new ones; the worn-out particles being dissolved in the fluid in which they are bathed. The fluid also is changed, since it has given up some of its important constituents.

Now the essential work of the lymphatics begins. The fluid containing this waste and worn out material sets toward the lymphatic meshwork, its volume ever increasing as it approaches the main channel on either side of the body, and reinforced, particularly during the hours of digestion, by the fluid food, rich in fat, which has been taken up by the intestinal absorbents. Then, as already stated, the current is borne along until the lymphatic trunk on either side of the neck joins one of the great veins, empties its contents into it and henceforth is merged in the blood stream. It is very interesting to note the manner in which this exchange of fluids takes place. The contractions of the heart furnish, of course, the central source of power. These and the elastic quality of the arteries propel the blood current into the capillaries and force it through the interstices of their thin walls into the tissues which surround them. The supply of fluid for their nutriment is constant and is as constantly renewed.

The lymphatic vessels, on the other hand, may be taken to represent an extensive animal membrane, placed between two fluids of different densities, and in accordance with the law of osmosis there will be a movement from the less dense to the more dense of these media.

But this alone does not answer the question satisfactorily. There is an element of porosity in the wall of the lymphatic vessels, and as the force of the heart wave is not entirely exhausted in the fluid which has been expelled from the blood capillaries, the remnant of it may readily be expended in pressing the fluid, which has done its work in nourishing the cells, into the lymphatic vessels.

Capillary attraction also will contribute to the setting of the current in these vessels, and this is aided by the contraction of the muscles from time to time and by the movements of respiration in the chest. The movement of the lymph current is always in one direction—from the periphery to the centre; and there are valves in the medium and large lymphatics which by their closure would prevent any backward setting of the lymph stream in case it were obstructed.

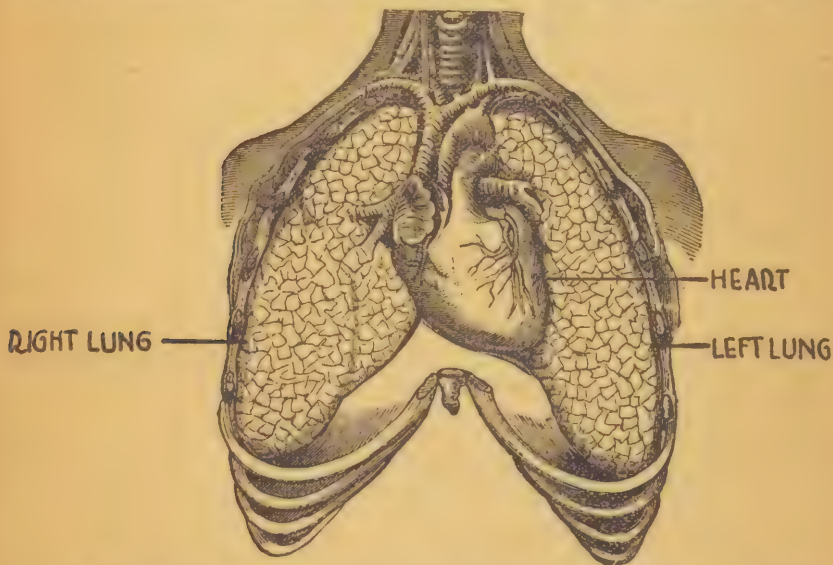
The quantity of fluid which is thus collected daily from the tissues of an adult of average size and weight is about four pounds. It can readily be seen from this how the weight and the nutrition of the body might suffer in case the lymphatic system were thrown out of commission and the blood failed to receive this daily contribution.

CHAPTER XIII

THE LUNGS AND BREATHING

Breathing or respiration includes the process of taking in oxygen and the changes which accompany it. Oxygen is the indispensable necessity of all life, whether animal or vegetable. There are some low forms of life among the bacteria called anaerobes which do not get it directly, but through the disintegrating and decomposing changes in animal or vegetable matter with which they are brought in contact.

The developing animal foetus is out of direct contact with oxygen, but it obtains it by way of the blood of its mother. Those who go down to the sea in submarines of course have no direct access to the atmosphere when



Cut VII. Chest Opened Showing Lungs, Heart and Beginnings of the Great Arteries (Doty)

submerged, but they obtain a supply of oxygen by producing the requisite chemical changes in substances with which it is combined. Should this supply give out or the machinery which produces it fail to work they would inevitably suffocate; and this is one danger which is ever present with them.

Plants that are exposed to the sunlight absorb carbonic acid and water from the atmosphere to form their cellulose, starch, and fat, and they exhale oxygen. This is one of the great sources of the illimitable supply of oxygen in the atmosphere, which forms one-fifth of its volume. Another great reservoir of oxygen is that which is dissolved in the waters of the earth and maintains their teeming life.

The absorption of oxygen is an essential part of the process of germination in seeds and in the expansion of the buds of leaves and flowers. Animals consume the organic material provided by plants, absorb oxygen from the air or from substances which contain it, and give out carbonic acid and water. Animals and plants are thus mutually dependent.

The respiration of the lower types of animals is through the skin. Even those as high in the scale as frogs and reptiles, though they have a well-constructed breathing apparatus, depend largely upon the skin for their supply of oxygen; which explains the facility with which they remain under water. In birds and mammals breathing is much more active than in reptiles and fish. The point in respiration is that the circulating fluid is on one side of a more or less porous membrane, while oxygen is on the other, the oxygen passing through the membrane and being taken up by the circulating fluid. On the other hand, carbonic acid passes out of the circulating fluid through the membrane and is conveyed out of the body as waste matter.

The respiration of fish is accomplished by means of gills which are bathed in water containing oxygen in solution. The gills are principally a mass of blood vessels which form the membrane serving as the medium for the interchange of oxygen and carbonic acid. In animals above a certain grade respiration is performed by means of lungs and their accessory parts. In man the respiratory apparatus begins with the larynx or glottis, the movements of which are synchronous with the expansion and collapse of the lungs.

From the larynx depends a flexible tube called the trachea or windpipe, which divides at its lower extremity into the right and left bronchus or bronchial tubes. These divide again, and continue to divide until the ultimate subdivision becomes a thin membranous tube terminating in an elastic sac, suggestive of a child's toy balloon. The interior of this sac is divided into compartments which expand and collapse as air enters and leaves them, their walls being filled with capillary blood vessels, through which oxygen passes to the circulating blood, while carbonic acid comes through them from the blood and is passed out with the exhaled air. Of course the spaces between these thousands and tens of thousands of tubes are filled with soft tissue to give the lungs the requisite shape and firmness, while the organs as a whole are completely covered with a membrane called the pleura, which passes over to the wall of the chest, and forms the internal lining of the chest cavity. Removed from the body, the lungs, trachea, and larynx are not a little suggestive of a huge bunch of grapes and its stem.

The surface included in this enormous number of minute blood vessels is very great, and a large volume of blood in a very thin layer can consequently be exposed at once to the influence of oxygen.

Besides this compressible, expandable, elastic mass of tissue in the lungs and their thousands of little air sacs, we have as assistants in the mechanism of respiration the muscular force of the diaphragm, which is the muscular partition wall between the cavities of the chest and the abdomen, the muscles between the ribs, the other muscles of the chest and abdomen, and the animating force of the nervous system—all of which, combined, cause the chest wall to rise and fall, the lungs to expand and collapse, the larynx with its vocal chords to open and close rhythmically

and regularly in a healthy adult about twenty times per minute. The rate is somewhat higher in children, and it may be lower during sleep and in the aged; it is considerably higher in certain diseases like pneumonia and pleurisy, and it is very low—perhaps not more than three or four per minute—in poisoning by opium.

When the chest is rigid from disease or otherwise the abdominal muscles endeavor to help out and relieve the difficulty, and when there is disease in the abdomen—for example, peritonitis—the abdomen is rigid and the chest muscles become unusually active.

In inhalation and exhalation, which are parts of one act, in an average adult 320 cubic centimetres of air are taken in and expelled. That is, about 10,000 litres per day are essential. This furnishes a basis for making calculations on the air capacity of rooms where large numbers of people are to be assembled, and it may be said in passing that it is very important to have this air in motion.

Only from ten to thirteen per cent. of the air which is taken in at one inhalation is expelled with the succeeding exhalation. In other words, there is always a large volume of residual air in the lungs, and eight or ten respirations will be necessary before these will contain an entirely new supply.

Air that is used in respiration consists mainly of one part of oxygen and four of nitrogen. When it gets to the lungs the blood pays no attention to the nitrogen, which is loosely combined with the oxygen, but selects only the latter, the hæmoglobin of the red corpuscles absorbing it and carrying it by means of the arteries to all parts of the body. Air that is exhaled, therefore, is deprived of more or less of its oxygen, and during its stay in the lungs it has acquired from the circulating blood watery vapor, carbonic acid, and a certain amount of waste matter.

The blood that goes from the heart into the arteries charged with oxygen is bright red in color, while that which comes back to the lungs by the veins after a journey over the body has lost its oxygen, has been charged with carbonic acid and waste matter, and is dark red, purple, or even black in color. If the oxygen of the air is reduced to one-half of its ordinary volume it becomes unfit for respiration. When a great many people are breathing a limited volume of air, as in a public building, the air becomes overcharged with carbonic acid, and it may also have insufficient oxygen. It is this excess of carbonic acid which often makes us drowsy in public gatherings, and perhaps gives us a headache which is relieved as soon as we get into the open air.

All of these facts should teach us the indispensable necessity of fresh air at all times and in all places, if we can get it. We must remember that if the blood is deprived of its essential oxygen, which is its food, the whole body becomes or may become a prey to ills of various kinds, because it lacks the resisting power which may be supplied by this necessary element.

CHAPTER XIV

THE HEART, BLOOD VESSELS, AND CIRCULATION

The heart and blood vessels together constitute the circulatory system, the object of which is to distribute the blood, with its nutritious and life-sustaining elements, to every portion of the body. Just as the water in a series of irrigating ditches carries moisture to the land through which it runs, the moisture being absorbed by the soil and vitalizing it, so the blood is the carrier of vitality to all the body's tissues and organs.

Without moisture there can be no fruitfulness; a dry soil is as sterile as the desert. Without blood there can be no life; the blood contains life, whatever that mysterious element may be.

The blood vessels not only convey the blood to all parts of the body, but they bring it back to the heart and lungs for purification before it starts again on its circuit. The blood is continuously in motion; should it stagnate or stop running in any portion of the body it would coagulate and harden and be no longer a part of the general circulation.

Should it stop running throughout the entire body, death would be the result; there is no circulation in a dead body.

The circulatory apparatus consists of the heart, arteries, capillaries, and veins. There is also a circulation in the lymphatics contributory to that in the blood vessels, but that does not concern us at present. The circulation starts from the heart as a centre, the elastic and contractile force of which pumps the blood into the arteries; the smallest arteries pass it into



Cut VIII. Course of the Blood Current to and from the Heart (Doty)

the capillaries, which irrigate and nourish each separate cell of the body, and then comes the return flow into the smaller and then into the larger veins, and finally an outpouring into the right upper cavity of the heart through two great trunk veins. Then the current passes into the right lower cavity, whence it is propelled through the pulmonary artery into the lungs. There it gives up its content of carbonic acid, which passes out with the air exhaled from the lungs, separates oxygen from the air in the air vesicles, absorbs it, flows back to the left upper chamber of the heart, then into the left lower chamber and thence is pumped out to renew its travel over the body. The force exerted upon the blood by the heart is aided by compression, fluidity and resistance as it moves through the different systems of vessels or tubes.

The ancients knew little, if anything, about the circulation of the blood. They were able to distinguish between arteries and veins from their observation of dead animals. They found blood in the veins, but the

arteries were empty; hence they supposed they carried only air, and the name which they still bear has that significance. It was not until the time of Vesalius (1514-1564) that dissections of the human body were legally and systematically made and taught. William Harvey (1578-1657) taught that the blood went out from the arteries and came back by the veins, but how the bridge between arteries and veins was crossed was not known until Malpighi (1628-1694) saw the capillary circulation in the lung of a frog by means of the microscope which he invented.

In mammalians the heart and lungs are interdependent, while in many of the lower orders of animals respiration is effected through the skin. All of the blood must pass through the lungs for aeration before it makes the circuit of the body. The heart is a muscular structure, cone shaped, fixed in the chest cavity with its apex downward, and surrounded by a membranous sheath called the pericardium. Its two small upper cavities are called auricles, and its two lower and larger cavities ventricles. The manner in which the blood passes through them has already been described. Between each auricle and ventricle is a valve which closes after each discharge of blood from auricle to ventricle, and between each ventricle and the great artery which is attached to it is another valve which closes after each discharge of blood from it.

These valves are frequently the seat of serious disease, particularly the valve between the left auricle and the left ventricle. Each contraction and relaxation of the heart is a pulsation or beat. As each pair of valves closes there is a sound—loud and long, then a second less loud and shorter. As the ventricles contract the end or apex of the heart moves forward and strikes the chest wall, forming the apex beat which can be seen if the chest wall is thin.

The two auricles contract simultaneously, then there is a period of rest, the contraction of the ventricles follows and another period of rest.

The arteries are strong elastic tubes ever becoming smaller from the centre to the surface of the body, and distributing the oxygenated blood to all its tissues and organs.

The force of the heart's contraction and the elasticity of the arteries propel the blood along, the valves of the auricles closing to prevent reflux of the blood after the auricles have contracted, and the valves of the ventricles doing a similar service after the ventricles have pumped their contents into the trunk arteries. The elastic pressure of the arteries also forces the blood into the capillaries by which it is distributed into every cell of the tissues of the body before it begins its return journey to the heart.

The average frequency of contraction of the heart is seventy per minute, modified, however, by age, sex, and physical condition. This number of contractions is repeated in the arteries and gives us the arterial pulse which is present in all the arteries throughout the body. The more rapid this pulse is the less its force, and consequently the less forcible the action of the heart.

Capillaries are minute tubes branching and combining together, invisible to the eye, permeating all the organs and tissues and intermediate between the arteries and the veins.

The veins are tubes which are less elastic and firm than the arteries, though, like the arteries, they are made up of three coats or layers. They receive the blood from the capillaries, and ever become larger from the surface to the heart, to which they bear the blood current.

The current within them must progress against gravity in much of its course, and they are provided with valves to prevent its back flow. They communicate with one another frequently, and those which are of any considerable size accompany arteries. The returning current is influenced in

part by the contractions of the heart and arteries, in part by the almost constant contraction of the muscles, and in part by the movements of the chest in respiration, but there is seldom any pulse in the veins.

The venous system holds more than the arteries; it is seldom full, and is very liable to become congested and cause discoloration of the surface when there is any obstruction to its flow. When the skin of a child in convulsions becomes dark or black it is due to congestion in the venous circulation.

The red globules of the blood are discoidal in shape and move freely in the blood stream. The white globules are relatively few in number, spheroidal in shape, and roll along in a curious way which is called amœboid movement. The walls of the capillaries being very thin, the blood easily passes through them and into the tissues it nourishes, by osmosis. Thus the necessary elements for the secretions of glands are provided, the capillaries of the villi of the intestine taking up the elements of digested food, while in the lungs the capillaries absorb oxygen and give out carbonic acid.

In the kidneys they discharge the products of destructive assimilation, especially the urea, which are removed from the body as urine; in fact, the capillary circulation furnishes the material for the growth and renovation of the body.

It takes about twenty seconds for the blood to make the circuit of the arteries, capillaries, and veins and get back to the heart for another journey. When organs or glands are working they contain more than four times as much blood as in repose, the blood then serving the ordinary purpose of nourishing the tissues and giving up the oxygen to them. In the lungs the blood absorbs oxygen and changes in color from dark to bright red. The composition of the blood differs as it comes from the different organs in which it has been circulating on its return course to the heart and lungs to be purified. Thus when it comes from the salivary glands it contains elements which have been concerned in making saliva, that which comes from the kidneys contains elements found in the urine, that from the portal vein, which comes direct from the intestines to the liver, has products of intestinal digestion, etc. The more we become acquainted with the working of the circulating apparatus the more must we become impressed with its wonderful character, and the important bearing it has upon all the problems of physical life.

CHAPTER XV

THE MOUTH, INCLUDING THE TEETH

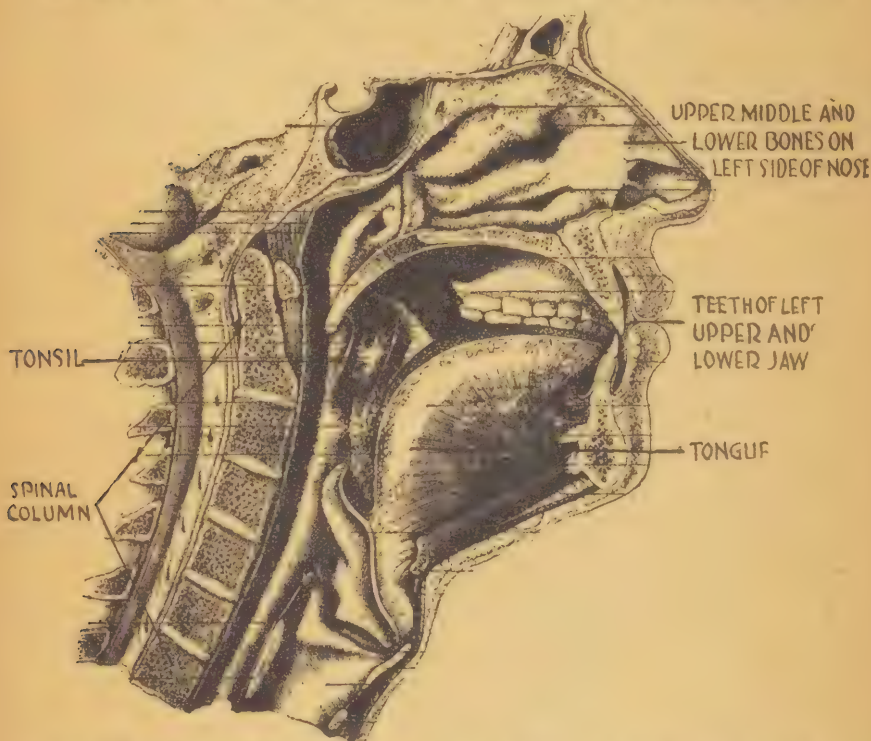
The part played by the mouth both in health and disease, and its relations to the rest of the body being so important, it is desirable to be informed concerning them.

The mouth includes the oval cavity and associated structures and tissues extending from the lips backward to the pharynx or throat. It is the beginning of the long and irregular tube called the alimentary or food canal. Under normal conditions all that is required for the nutrition of the body, whether solid or fluid, must first pass this portal. It is also the gate by which much that is harmful is admitted to the body, including germs of disease and deleterious solid, fluid, and gaseous matter connected with trades and occupations. It contains the tongue, the teeth, and their alveolar process or socket, the hard palate forming its roof, the soft palate with its little uvula hanging from it, the tonsils, the openings to the canals which lead to the salivary glands, and on either side of its back portion two structures called the pillars of the soft palate. This entire cavity,

and all the structures connected with it except the teeth are covered with mucous membrane containing glands which secrete mucus for its lubrication.

The salivary glands include the two large parotid glands under each ear pouring their saliva through a duct or canal opening at the back part of the upper jaw, the two submaxillaries at the back of the lower jaw pouring their saliva into the front part of the mouth under the tongue and the sublingual under the tongue, which discharges its secretion near that of the submaxillary.

The saliva is composed almost entirely of water, but it contains a small quantity of very important digestive juice called ptyalin, which begins the



Cut IX. Vertical Section Through the Middle of the Skull and Neck (Sappey)

digestion of the starchy food taken into the mouth, changing a portion of it into sugar.

The tonsils are glands, one on each side, between the pillars of the soft palate. They yield a viscid secretion and are extremely susceptible to disease and enlargement. These, with glandular enlargements on the mucous membrane called adenoids at the back of the mouth, often cause great trouble, especially to children—not only interfering with breathing, but sometimes with the general nutrition.

The tongue is a muscular structure attached at the back portion of the mouth, covered with mucous membrane and somewhat restrained in its movements by a cord-like band underneath. If this band extend well to the front of the tongue it causes the deformity known as tongue-tie.

The tongue is the organ of taste; it is very useful, both in mastication and speech, but is not essential to either. It is abundantly supplied with nerves by the aid of which discrimination in taste is possible. The roughness of its upper surface is due to the little elevated structures called papillæ which cover it and which are supplied with the nerves and cells by which taste and touch are determined.

The teeth are fixed in a bony socket attached to each jaw called the alveolar process. It is covered with fibrous tissue, and this with mucous membrane which is a part of that which lines the entire cavity of the mouth.

There is a temporary and a permanent set of teeth—the former containing twenty and the latter thirty-two. Of the latter in each jaw there are four incisors and two canines for cutting and tearing the food, four bicuspidis for preliminary grinding, and six molars for final grinding and trituration. Under favorable conditions the temporary teeth are gradually crowded forward by the permanent ones, the position taken by the latter being governed by the shape of the jaw bones, by the conditions of nutrition in the individual case, and by the care and attention which have been given to the temporary teeth. In well-shaped jaws there is room enough for the entire thirty-two teeth, which usually begin to appear at the seventh year, the third molars or final ones coming from the seventeenth to the twenty-first year.

The teeth are very susceptible to disease, especially if the general condition is poor or the food improper.

The mineral elements of the food, especially the lime salts, are essential to proper development and stability of the teeth. Germs frequently attack them, for no part of the body is so overrun with germs in great variety as is the mouth. The hygiene and care of the teeth should be persistently taught and enforced from earliest childhood, and the brush, toothpick, and a simple dentifrice like powdered chalk should be in universal use.

The greatest care also should be given to mastication. Food cannot be digested until it is liquefied, and careful cutting and grinding, rolling about with the tongue, and saturation with the saliva enable the ferments of the stomach and intestine to permeate and dissolve it—which they cannot readily do if it is bolted down whole or only half masticated.

Much of the indigestion from which people, and especially children, suffer is caused by imperfect preparation of food for the action of the digestive ferments.

CHAPTER XVI

THE STOMACH AND INTESTINES

Passing backward from the front, the mouth merges into a cavity or space called the pharynx or throat, which is sometimes spoken of as the expanded upper end of the digestive tube. Not only does the mouth terminate posteriorly in the pharynx, but so also do the nasal passages, and a somewhat rigid tube called the œsophagus or food conductor, about ten inches long in the adult, leads vertically downward to the stomach.

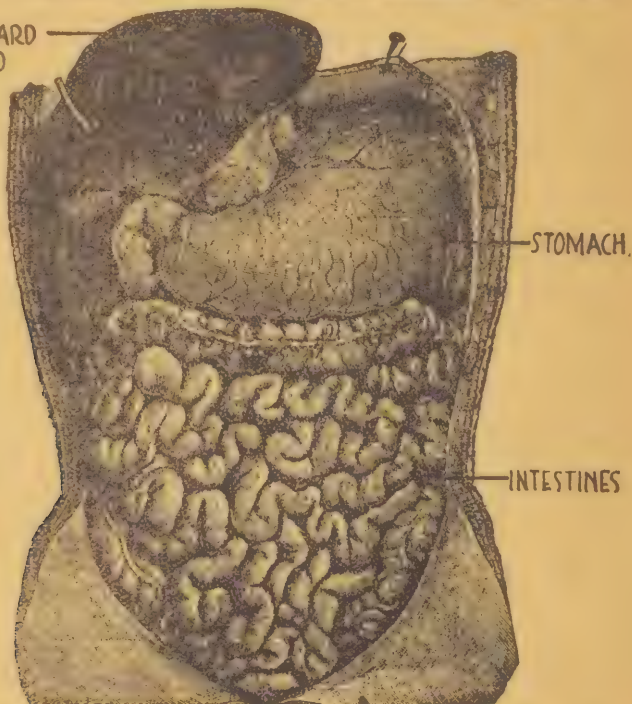
The action of substances passing from the mouth to the stomach is not comparable to the pouring of a solid or a liquid into a funnel or into a metallic tube, vertically held. In the latter case the force of gravity overcoming the very slight resistance of the wall of the tube permits the substances to pass uninterruptedly through and out of the tube. In the former case, solid or fluid having reached the throat, there is forcible contraction of the throat muscles, the substance is compressed and propelled

downward and the wave of propulsion continues until it is landed in the stomach.

The stomach is a hollow organ shaped somewhat like a rowboat, the bow to the right of the middle line of the body and the stern five or six inches to the left. It lies horizontally in the uppermost part of the abdominal cavity under the diaphragm, which is the muscular partition separating the abdominal from the chest cavity—the latter containing the heart and lungs. It is concave on its upper surface and convex on its lower. It narrows down like the neck of a bottle at the right extremity, and is expanded and full at its extremity on the left.

It is made up of three coats or layers. The outer is a part of the great peritonæal membrane which lines the entire abdominal cavity, and

LIVER PULLED UPWARD
AND BACKWARD TO
SHOW STOMACH.



Cut X. Skin and Muscles Removed Showing Intestines, Stomach and Upturned Liver (Doty)

is the outer coating of all the organs it contains. The middle layer is muscular, the fibres being longitudinal, circular, and oblique in their disposition. When digestion is in progress all these fibres contract, and the resultant is a churning motion by which the contents of the stomach are moved back and forth, from one end to the other, until they are emptied through the opening into the small intestine called the pylorus at the extreme right of the organ.

The inner layer of the stomach is composed of mucous membrane, the peculiarity of which is that it is thickly covered with minute glands of two varieties; one of them secretes mucus with which the stomach in its normal condition is always plentifully supplied, and the other secretes the acid gastric juice, containing hydrochloric acid and pepsin, which

digests the proteid or albuminoid food substances, including meat, white of egg, and the albuminous portion of vegetables.

The stomach is abundantly supplied with blood vessels, lymphatics, and nerves, is susceptible to and is often the seat of pain, and is quite prone to disease. Not only are there myriads of cases of disease resulting from indigestion, often terminating in ulcer, but there are many cases of cancer—more than in any other organ of the body.

This is not strange when we realize how constantly the stomach is used and how fearfully it is abused. When it is actively engaged in the work of digestion—that is, for three hours after a meal—its vessels contain two or three times the quantity of blood which they hold when inactive.

It may be dilated with gas or fluid from excessive eating or drinking or the indigestion and fermentation which come from such indiscretion; consequently it may become greatly enlarged, its digestive function impaired, and when so dilated and weakened it may drop from its normal position to the lowermost portion of the abdominal cavity.

In a normal condition the capacity of the adult stomach is two or three pints; when dilated it may contain two or three times that quantity. It may also be atrophied and shrivelled, and may even be removed by a surgeon altogether—as has happened in not a few instances; the first portion of the intestine, called the duodenum, dilating to compensate for its absence. The intestines begin where the stomach ends on the right side of the abdominal cavity. They are divided into small and large, the former about twenty feet in length, the latter five.

The small intestines are distributed in coils more or less irregularly through the abdominal cavity, being loose and movable in front, but attached behind to the spinal column or backbone by a prolongation of their peritoneal covering. They end in the lower portion of the right side of the abdominal cavity, merging into the large intestine. One portion of this passes downward a few inches, forming the cæcum or blind pouch, and to its extremity is attached that remarkable little tube which has caused so much trouble, real and imaginary, in so many thousands of human beings—the appendix vermiformis.

The other portion of the large intestine passes vertically upward until it reaches the liver, when it bends and passes transversely across the abdominal cavity. As it approaches the spleen on the left side of this cavity it bends downward, passing through one side of the pelvis till it reaches its termination.

Both the small and the large intestine are made on the same plan as the stomach—the peritoneal coat for protection, the muscular for motion, propelling its contents forward in a wave-like manner called peristalsis, and the mucous for the secretion of glandular material, for digestion and lubrication.

The absorbent apparatus of the mucous membrane of the small intestine, like a sponge, gathers up the digested material and transfers it to the blood stream. In a somewhat arbitrary manner—for it is difficult to say where one part ends and other begins—the small intestine is subdivided into three sections, the duodenum, jejunum and ileum. The first of these, eight or ten inches long, is the most important, for it receives the proteid material which has been digested and liquefied by the stomach and the as yet undigested starches and fats.

Into this portion of the intestine, by means of a suitable tube from each organ, the bile from the liver and the pancreatic juice from the pancreas are poured, digesting the starches and fats which have arrived there, and further aiding in the digestive process.

The second portion, or jejunum, is about eight feet long, the third portion, or ileum, taking up the remaining eleven feet. The mucous membrane of the small intestine is arranged in folds or valves, and in these are implanted the villi or absorbent structures, millions in number, by which the digested food material is sucked up to be transferred to the blood stream, and furnish the nutriment for the tissues of the body.

All the digested material may not be absorbed, and that which remains undigested is unfit for absorption, this residue being swept along into the large intestine.

There is a certain amount of absorption from the large intestine, but it is chiefly a reservoir for waste material, which accumulates at its lower end, called the rectum, from which it is discharged from the body.

In addition to the absorbent structures of the mucous membrane of the small intestine, both the small and the large intestine are plentifully provided with a variety of glands which are more or less associated with the digestive process. One set of them, called Peyer's glands, of the small intestine forms the chief element of disease in typhoid fever.

CHAPTER XVII

THE LIVER, PANCREAS AND SPLEEN

The liver occupies the right upper quadrant of the abdominal cavity, is the largest organ in the body—weighing in the healthy adult about four pounds—and has a very complicated structure and function.

One has only to notice the liver of an animal displayed in the meat shops to recall that it suggests in shape an inverted bowl, its convex, upper surface fitting into the concavity of the diaphragm (the dividing partition between the cavities of the abdomen and the chest), while its concave, lower surface is in contact with the intestines, stomach and right kidney. It is not in one mass or piece, but is divided by a firm ligament or band into two unequal parts, while from its under surface project three small accessory masses.

To its under surface also is attached a small sac called the gall-bladder, which is a temporary reservoir for superfluous and unused bile, and is frequently the seat of a very painful and troublesome inflammatory disease usually attended with the formation of smaller or larger masses of solid material called gall-stones.

The liver, like all the other abdominal organs, is covered by the great membrane called the peritoneum. It is supplied abundantly with veins, arteries, nerves and lymphatics; but the essential part of its structure as a secreting organ consists in millions of small bodies called hepatic lobules, a tenth of an inch or less in diameter, and composed of liver cells, packed closely together.

Each lobule contains at its border a branch of the great vein called the portal vein, which brings to the liver from the stomach, spleen, pancreas, and small intestine blood charged with the products of digestion.

Each of these surrounding branches sends little twigs to the interior of the lobule, where they unite in one vein connected with the general system of veins of the liver.

The product of the cells of the lobules of the liver is a brownish-green fluid called bile. It is gathered up by the minute bile-channels surrounding the cells, delivered into larger and larger channels, and finally discharged into a large duct or canal passing from the lower surface of the liver into the duodenum or first portion of the small intestine.

Bile is a very complex substance, containing in 1,000 parts 977 of water, the remainder consisting of important organic matter and mineral salts. The

bile plays a more or less important part in the process of digestion. Just what it does it is difficult to say, but it is essential to this process. An adult of average size and weight secretes about two pints daily.

Another important function of the liver is that it serves as a reservoir within its substance for glycogen or animal sugar. This is brought to the liver, in the form of glucose, in the blood conveyed by the great portal vein from the digestive organs. The glucose is changed by the chemistry of the liver into glycogen, and when there is a requirement for glucose on the part of the tissues of the body the glycogen is changed back again into glucose and carried by the blood to the portion of the body which needs it.

The pancreas is a small gland somewhat triangular in shape, about six inches long and one and a half wide, lying transversely across the abdominal cavity between the first portion of the small intestine and the spleen, and weighing from two to six ounces. Small though it be, it is intensely active, and absolutely essential to the processes of digestion. Its duct pours the secretion of the gland into the duodenum just below the duct which discharges the bile from the liver. Its secretion is called pancreatic juice, and contains nearly 10 per cent. of albumenoid substances, having powerful action in emulsifying the fats which have come from the stomach to the duodenum undigested.

It also includes powerful ferments which convert the starchy elements of the food into sugar, thus preparing both starches and fats for absorption and assimilation. Furthermore, it has a certain degree of power to digest albumen. More than a pint of fluid is secreted daily by this busy gland.

When we realize that starches and fats form the principal part of the food of the majority of the inhabitants of the globe, we can see what a tremendous influence this little organ has upon animal life.

The spleen, like the liver and pancreas, is a gland and, therefore, has its juice or secretion; but, unlike these organs, it has no duct or canal by which its secretion can get out. It is one of a group of ductless glands which include the pineal, the thyroid, and the supra-renal capsules. Its secretion is taken up by the blood-current and carried to those portions of the body where it may be needed and utilized. Precisely what its function is we do not as yet know, but it is believed it has an important influence upon the digestive process, and an extract obtained from it is sometimes used in the treatment of indigestion.

The spleen is not absolutely essential to life; it is subject to diseases and tumors of various kinds, and in malarial poisoning and typhoid fever is greatly enlarged and often becomes more or less disorganized. In shape it resembles a bean, and lies lengthwise on the left side of the abdominal cavity below the diaphragm, in contact with the left extremity of the stomach near the bend of the transverse portion of the large intestine. In the adult it is about five inches long, three or four inches wide, an inch to an inch and a half thick, and weighs seven ounces or more.

Another consideration which gives it importance is that it is one of the sources of origin of the white corpuscles of the blood.

CHAPTER XVIII

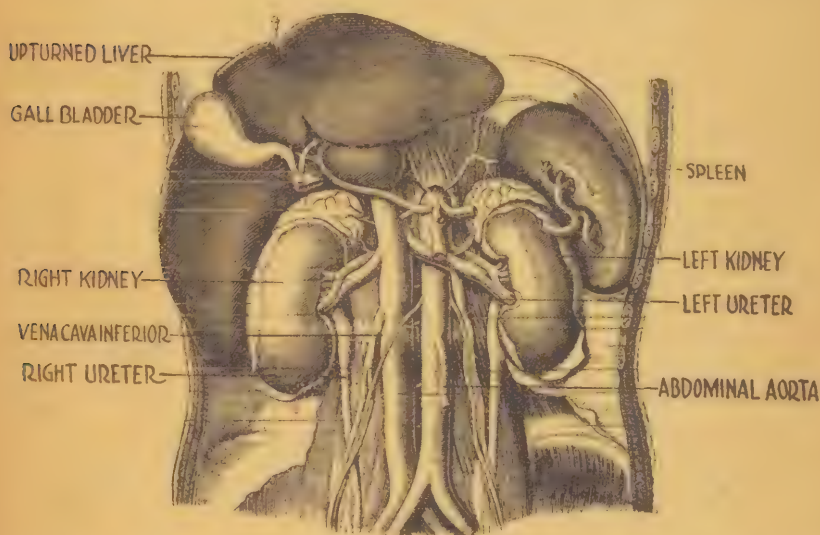
THE KIDNEYS AND BLADDER

The kidneys and bladder, together with the tubes called the ureters—which form the connecting links between them—constitute the urinary system, the object of which is to separate from the blood the urine, with the contents it holds in solution, collect and store it for a suitable period, and then discharge it from the body. This plan is imperatively necessary,

for the waste matters dissolved in the urine are poisons, and if there is any fault in the filtering apparatus of the kidneys which prevents its removing them from the blood the reaction will be apparent, especially in the nervous system, within a brief period—usually within a day or two; and unless the fault can be remedied and the kidneys induced to perform their customary function the result will be fatal. Furthermore, if there is obstruction in either ureter which prevents the free passage of urine from the kidney to the bladder serious and even fatal results will follow; and, finally, bad results also will follow if the urine is retained longer than six or eight hours in the bladder.

The urinary organs are probably subject to as much abuse as any of the organs of the body, therefore it is not strange that they should be the seat of so many interesting and important diseases.

The kidneys are located one on either side of the backbone, embedded



Cut XI. Kidneys with the Artery Vein and Ureter Belonging to Each. Liver Upturned Showing Gall Bladder. Spleen. (Sappey)

in fat, at the rear of the abdominal cavity—but not within it, in the region called the loins, extending from the eleventh rib to the upper border of the bones of the pelvis or haunch.

The kidney, roughly speaking, is four inches long, two in width, and one in thickness, and weighs from four to six ounces. In appearance it closely resembles a lima bean, and on its top is a small, ductless gland called the supra-renal capsule, which has no immediate connection with the kidney or with its function, and is supposed to be related in some way with the sympathetic nervous system. Its convex border is outward, and its concave inward, not far removed from the backbone. At the middle of its inner border is a depression, and to this is attached the ureter, which bears away the urine as it accumulates in the little reservoir called the pelvis, and the artery and vein by which it derives its blood supply.

Within the kidney there is an outer thick layer of glandular tissue called

the cortex, and below it a closely connected series of pyramidal tubes called the medulla.

The glandular apparatus of the cortex separates the urine from the blood circulating through it, and the pyramidal structures collect it and discharge it drop by drop into the pelvis, whence it is conveyed by the ureters to the bladder.

The system of tubes through which this filtration takes place is a very complicated one—too complicated to be understood except after careful study—and its description would hardly be intelligible to the ordinary reader.

The ureters are cylindrical membraneous tubes, sixteen to eighteen inches long, running from the pelvis of the kidney obliquely downward and inward, then forward across the bony pelvis, and terminating at the rear of the base of the bladder.

There is a more or less continuous stream of urine trickling down these tubes into the reservoir or bladder. If this channel is occluded, as it frequently is by a stone working its way down from the kidney, by a new growth or some other obstruction within, or by pressure from without, the result will be a damming back of the urine within the kidney and the formation of a tumor which may reach large proportions.

Only a serious surgical operation can relieve such a difficulty, and one requiring great skill and judgment.

The bladder is a balloon-like sac lined with mucous membrane in the front of the bony pelvis, with a middle coat of muscular tissue, which, by contracting, squeezes out its contents through the duct called the urethra. The outer coat of the bladder is composed of peritonæum, which, however, does not cover it entirely, in front and below. In the adult its capacity is about one pint, and when its contents rise to a certain level, varying with different individuals and with individual sensitiveness, there is an impulse or desire to expel it; and if there is no obstruction in the outlet the contraction of the muscular coat will effectually cause its evacuation.

If there should be an obstruction in the urethra, or the mucous membrane should be so insensitive that the desire to evacuate it is not felt—as is the case in diseases and injuries of various kinds—the urine accumulates and the bladder is distended like an inflated balloon. This may continue to the bursting point or until artificial evacuation is performed.

Imperfect or incomplete emptying of the bladder and retention of more or less of the urine is followed in a short time by decomposition, the development and absorption of poisons and serious consequences. It is, therefore, imperative, if the bladder and the entire body as well, are to remain in a condition of health, that it be completely emptied at suitable intervals.

CHAPTER XIX

DIGESTION AND ABSORPTION

Digestion means the preparation of food for absorption, which in turn is followed by assimilation; the cells of the various tissues taking from the blood which is supplied to them through the capillary circulation the various elements—albumen, fat, sugar, and mineral salts—according to their requirements.

Digestion also means that food is reduced from a solid to a liquid condition, for it can be absorbed only as a liquid. This reduction is accomplished by means of water and the ferments of the mouth, stomach, and intestines, aided by certain mechanical factors.

Food having been introduced into the mouth, torn by the teeth, or in a condition already prepared for use, is first subjected to mastication by the

teeth; the incisors tear it, the canines and bicuspid give it preliminary crushing and grinding, and the molars finish with grinding and tritulating. The tongue assists in rolling the bolus of food about, and the fluid from the salivary glands permeates it with moisture. But the saliva does more than supply water to the food while it is in the mouth, for it contains a minute quantity of a ferment called ptyalin, and this has the property of changing starch into sugar.

Some of the starch, therefore, which is taken for food is converted into sugar in the mouth. Masticated and softened, and with a small portion of its starchy elements already changed to sugar, the food is next swallowed and conveyed to the stomach.

The secretion of the glands of the mucous membrane of the stomach is called gastric juice and is thrown out only or mainly when the stomach contains food. In 1,000 parts it contains 975 of water, 4.78 of hydrochloric acid, 15 of pepsin, and the remainder of mineral salts.

The softened food of the mouth is usually a mixture of animal and vegetable food containing, of course, mineral elements: In physiological language it is known as albumenoids or proteids, including meat, eggs, fish, milk, and certain portions of the cereal grains, and starches and fats, including all vegetables and plants and both animal and vegetable fat. Of this mixture the gastric juice pays no attention to the starches and fats, but it permeates the proteids, disintegrates and liquefies them. During this operation the entire mass of food in the stomach is churned back and forth by the contraction of the muscle fibres in its wall.

As liquefaction proceeds the stomach contents are gradually—that is, in the course of two or three hours—emptied into the duodenum or first portion of the small intestine at the extreme right of the stomach below the liver. Into this portion of the intestine and at its very beginning are poured the secretions from the pancreas and liver, and when the current from the stomach arrives it is promptly met and acted upon by the bile and the pancreatic juice.

The action of the bile upon digestive fluids is not definitely known, but it dilutes them and has the power of dissolving fats to a moderate degree. It also stimulates the intestines to contract and propel onward the fluids they contain.

The pancreatic juice contains powerful ferments, which begin at once to act upon the starches and fats with which they come in contact in the duodenum. The fats are immediately emulsified—that is, they are broken up into globules infinitesimal in size, which can be absorbed through the proper structures in the intestine, and find their way into the blood-current for distribution over the body. Some of the fat is not thus changed, but is subsequently converted into a fatty acid. The starches are broken up, liquefied, and converted into sugar by the pancreatic ferments, and, furthermore, these ferments complete the digestion of certain albuminous elements which may have escaped digestion by the gastric juice. A certain amount of digestion also is accomplished in the small intestine by the action of the juices of the intestinal glands.

The quantity of this secretion is small and its digestive power weak. It is similar to the pancreatic juice in emulsifying fats and converting starch into sugar, but not in sufficient degree to have any material effect upon the digestive process as a whole. In the large intestine the glands are far fewer than in the small, and their secretion is very limited. The work of digestion is practically completed when the intestinal contents pass through the valve separating the small from the large intestine.

The secretion of the large intestine gives this matter an offensive odor; its excess of water is absorbed by the mucous membrane, and the remainder

is propelled to the reservoir at the end of the intestine, to be expelled in due season from the body.

Absorption of the fluid nutrient product of digestion takes place in the absorptive apparatus of the mucous membrane of the small intestine, just as a sponge soaks up the fluid in which it is immersed.

This apparatus consists of millions of little cone-like structures called villi, inserted in the mucous membrane from its beginning to its end.

Over the larger portion of the small intestine the mucous membrane is arranged in folds or valves about one-third of an inch in height, and in these folds the villi are set or implanted. Each one of them consists of an outer layer of epithelial cells, which acts as a dialysing membrane, through which the nutrient fluid passes.

Within the cone is a minute artery and a minute vein, and between them a series of extra-minute capillaries. In the centre of the cone is a minute lymphatic vessel, around which are the blood vessels just mentioned.

Imagine the amount of absorbing surface in four or more millions of villi all built after this type. The nutrient fluid having passed through, the covering membrane of the villi is taken up by the capillary vessels within; but a portion of it—especially the fine particles of fat—is absorbed by the lymphatic vessels of the villi and carried with the lymph stream, which finally empties into one of the great veins on either side of the neck. Thence it is borne to the right side of the heart.

The blood in the capillaries containing the digestive fluid is carried by the veins from the intestines to the great portal vein, which bears it to the liver. It circulates through the capillary vessels of that organ, and the sugar which it contains is deposited within the liver tissue.

The albumen continues in the blood as an essential element to the extent of fifty-three parts per thousand. It is subsequently appropriated from the blood by the tissues of the body as required.

The sugar in the liver is transformed into glycogen or liver-sugar, and then changed back again into animal sugar or glucose and transported by the blood to the tissues when it is so required, or decomposed or otherwise changed. The fat is carried by the blood from the heart to the lungs, where it is chemically changed, losing its characteristic oily appearance; or a portion of it may be deposited in the fatty tissues of the body.

CHAPTER XX

REPRODUCTION AND THE REPRODUCTIVE APPARATUS.

All through the series of vegetable and animal life, reproduction, preservation of the species is the dominant thought.

When individuals in a species are poorly provided with reproductive powers and apparatus they dwindle and become unimportant in successive generations and finally the species becomes extinct.

Both animals and plants must have favoring surroundings as to climate, food, shelter, soil, etc., in order to produce abundant and healthy offspring and when these conditions are present there is little difficulty with reference to the continuance of the species.

The laws which affect reproduction in man are the same as those which affect what we call the lower animals. Given two individuals male and female, of good physical inheritance and development, without great disparity as to age, in early or middle adult life, able to obtain the necessities of life without unusual effort and struggle, and not disposed to repress the natural desire for offspring, they will breed freely and their children will certainly have average physical development. Their mental development

will depend largely upon social and home surroundings and upon the educational advantages which may be available.

The male external organ of generation is attached to the bones at the front of the pelvis, above and below, and its urethra or central canal is continuous with the bladder. At its base it is surrounded by a collar-like structure called the prostate gland, which is almost invariably enlarged in old age and often the seat of serious disease. Its removal by modern surgery is often a life-saving procedure, and a triumph of surgical art. So far as this gland has any apparent purpose it seems to be to consolidate the union between the organ of generation and the bladder.

The continuity of the urethra with the bladder enables it to serve as the duct or outlet through which the bladder is emptied. The bag or sac behind the genital organ is called the scrotum and contains the essential male organs of generation, the two testicles. In these two glands the male generative fluid or semen is secreted. A duct or canal conveys this secretion backward into the pelvis to the base or under surface of the bladder, where on either side there is a small reservoir called the seminal vesicle. From this reservoir it is conveyed forward to the urethra through which it is discharged.

The female generative organs are the vagina, uterus or womb, Fallopian tubes, and ovaries. The vagina is merely the tube or passage leading to the uterus. Within the vagina is a portion of the uterus called its neck or cervix. Above this, consequently above the vagina, and within the pelvis, is the upper portion or body of the uterus.

The uterus resembles a pear or cone in appearance, with base upward and apex downward. At right angles from either side of the base, for about four inches, extends a twisted tube with a very narrow canal flaring out at its remote end like the bell of a trumpet. This is the Fallopian tube by which the ova or eggs are conducted from the ovary to the uterus.

The ovaries are the essential generative organs of the female one on either side of the uterus. They are oval and about as large as a good sized olive, but somewhat flattened. Each is attached by a ligament at one end to the uterus, and by one at the other end to the Fallopian tube.

The ova are developed in the substance of the ovary, the process of formation beginning with the formation of the ovary before birth and continuing to the end of the child-bearing period. These ova, about 1-125 inch in diameter are also being constantly shed or cast off, some passing into the pelvis and quickly undergoing disintegration, solution and absorption, others being drawn into the Fallopian tube and disappearing in the mucus it secretes, still others being propelled along the tube and uterus to be finally extruded from the body.

In suitable cases the ovum is impregnated and it is by this means that the species is maintained and the race survives. The ovary in the human female is a very small organ and is little if any larger in the mammalia as large as the cow and horse, but it is relatively far larger in the lower orders of animals, especially in the fish.

The human ovaries may contain, from first to last, as many as 70,000 ova or eggs, most of which are existent at the time of birth, while the ovaries of a good sized salmon or shad may contain millions.

It is on such a prodigal scale as this that nature works in order to preserve species.

It is believed that impregnation usually occurs in one or the other of the Fallopian tubes. Ova are almost constantly working their way from the ovaries toward the uterus and in this progress one of them may be met and invaded by a spermatozoon. The spermatozoa are the impregnating organisms of the seminal fluid and in the healthy secretion are relatively as

numerous as ova in the ovary. Seminal fluid which does not contain living, active spermatozoa is sterile and fruitless. The shape of the spermatozoon is suggestive of a tadpole, and if healthy and active it may retain its impregnating capacity eight or ten days. One spermatozoon impregnates one ovum, though two or three or even more may impregnate the same.

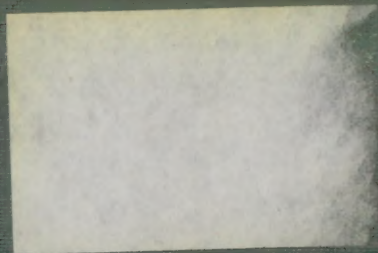
The spermatozoon is endowed with motion which is usually forward. Meeting an ovum it attacks it head first, the head penetrating the ovum, the tail being left outside and soon disappearing.

The entrance of the spermatozoon soon sets up chemical and biological changes, cellular life and activity begin, and thenceforward embryonic life progresses. Sometimes the impregnated ovum instead of going forward and developing normally within the uterus remains and develops within the tube, frequently causing serious accident and death, unless the abnormality can be discovered and remedied by a timely surgical operation.

In the great majority of cases the impregnated ovum is impelled forward into the cavity of the uterus, there makes a bed or nest for itself, and then undergoes those marvellous and beautiful changes which the development of life implies. In due season the mature foetus now capable of an independent existence emerges into the world and begins its new life, as the fruit drops from the tree or the butterfly springs from the chrysalis.

SGL

MAR 12 1918



NATIONAL LIBRARY OF MEDICINE



NLM 00043134 9